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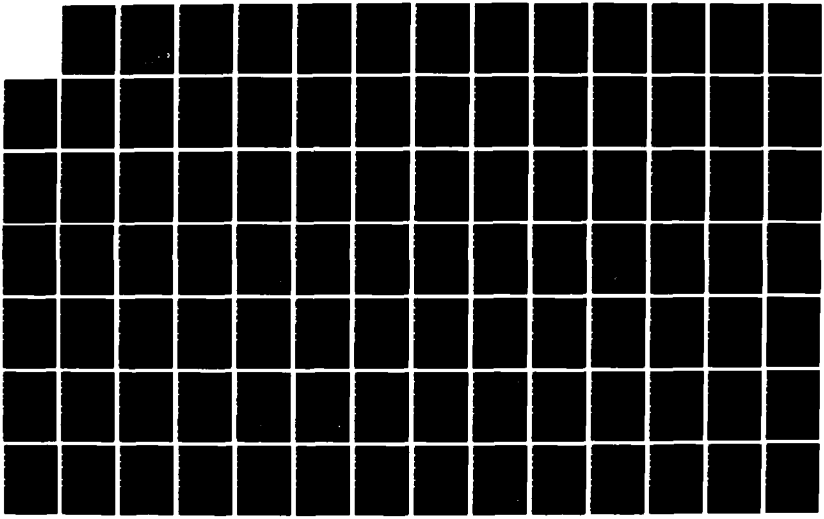

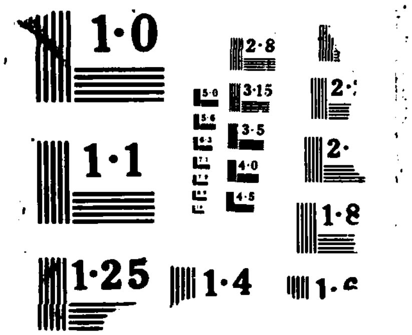
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AD-A194 972

Installation Restoration Program
Phase II - Confirmation/Quantification
Stage 1

Final Report
For

Otis Air National Guard Base, Massachusetts
Air National Guard Support Center
Andrews Air Force Base, Maryland

Prepared For

United States Air Force
Occupational and Environmental Health Laboratory
(USAF OEHL)
Brooks Air Force Base, Texas
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A Problem Confirmation Study was performed at seven sites on Otis Air National Guard Base: the Current and Former Fire Training Areas, the Base Landfill, the Nondestructive Inspection Laboratory, the Fuel Test Dump Site, the Railyard Fuel Pumping Station, and the Petrol Fuel Storage Area. The field investigation was conducted in two stages, in November 1983 through January 1984, and in October through December 1984. Resampling was performed at selected locations in April and July 1985. A total of 11 monitor wells were installed and sampled and test pit investigations were conducted at six sites. In addition, the contents of a sump tank, and two header pipes for fuel transmission lines were sampled. Analytes included TOC, TOX, cyanide, phenols, Safe Drinking Water metals, pesticides and herbicides, and in the second round, priority pollutant volatile organic compounds and a GC "fingerprint" scan for fuel products. On the basis of the field work findings, it is concluded that, to date, water quality impacts on groundwater from past activities have been minimal.

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INSTALLATION RESTORATION PROGRAM

PHASE II - CONFIRMATION/QUANTIFICATION

STAGE 1

Final Report
for
Otis Air National Guard Base, Massachusetts
Air National Guard Support Center
Andrews AFB, MD

September 1985

Prepared by

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Contract No. F33615-80-D-4006, Task Order 28

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USAF OEHL Technical Monitor
Technical Services Division (TS)

Prepared for

UNITED STATES AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY (USAF OEHL)
BROOKS AIR FORCE BASE, TEXAS 78235-5501

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This report has been prepared for the U.S. Air Force by Roy F. Weston, Inc. for the purpose of aiding in the implementation of the Air Force Installation Restoration Program. It is not an endorsement of any product. The views expressed herein are those of the contractor and do not necessarily reflect the official views of the publishing agency, the United States Air Force or the Department of Defense.

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PREFACE

A Phase II, Stage 1 Installation Restoration Program (IRP) Problem Confirmation/Quantification Study was performed at Otis ANGB between November 1983 and September 1985. Lt Col Edward S. Barnes, Technical Services Division, USAF Occupational and Environmental Health Laboratory (USAF OEHL) was the Technical Monitor.

The confirmatory investigations at seven suspect sites were performed by Roy F. Weston, Inc. under Contract No. F33615-80-D-4006 Task Order No. 28. The two-part field study focused on four sites in the November 1983 to March 1984 period; since October 1984, three additional sites and the four original sites have been the subject of continuing study. The intent of the Stage 1 investigations was to determine whether or not former activities at seven sites at Otis ANGB pose a significant current or future environmental health threat based upon the analytical findings and the hydrogeologic setting. Each site was ultimately categorized based upon the need for further monitoring, remedial action, or a determination that no further actions are warranted.

The study was conducted by WESTON personnel and managed through WESTON's Concord, New Hampshire Office. Messr. David Woodhouse P.G. and Glenn R. Smart were the field team leaders during the course of the investigations. Richard L. Kraybill P.G. managed the project and with Glenn R. Smart, provided the principal authorships of the study. Sample analyses initially were performed under the direction of Dr. James Smith and, since November 1984, under the direction of Dr. Earl Hansen. Technical Quality Assurance/Quality Control (QA/QC) review of the report was conducted by Dr. Frederick Bopp, III P.G., Contract Manager, and Mr. Walter Leis, Vice President and Director of WESTON's Geosciences Group. Mr. Peter J. Marks, Vice President, is WESTON's Program Manager for this contract. Mr. Marks provided the overall project direction and liason between WESTON and the USAF OEHL.

In appreciation, WESTON would like to acknowledge the cooperation of the personnel at Otis ANGB for site access and additional data acquisition from Base records, and the guidance of Lt Col Edward Barnes through this extended field study program.

Approved By

Peter J. Marks
Name

Program Manager, V.P.
Title

6 September 1985
Date

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EXECUTIVE SUMMARY

PROGRAM HISTORY AT OTIS AIR NATIONAL GUARD BASE

Roy F. Weston, Inc. (WESTON) has been retained by the United States Air Force Occupational and Environmental Health Laboratory (USAF OEHL) under Basic Ordering Agreement (BOA) Contract Number F33165-80-D-4006 to provide the Air Force with general engineering, analytical, and hydrogeological services. The Phase I, Problem Identification/Records Search at the Otis Air National Guard Base (Otis ANGB) was conducted by Metcalf & Eddy (M&E). The Phase I Final Report was submitted to USAF OEHL in January 1983. In response to the findings contained in the M&E Phase I Final Report, the USAF OEHL issued Task Order 0018 to WESTON, directing that a presurvey be conducted at Otis ANGB to obtain sufficient information to start a full Phase II, Problem Confirmation and Quantification Study.

The Phase I Report prioritized six potential problem areas shown in Figure S-1:

- Site 1 - Current Fire Training Area (CFTA)
- Site 2 - Former Fire Training Area (FFTA)
- Site 3 - Base Landfill
- Site 4 - Avgas Fuel Test Dump Site (AFTDS)
- Site 5 - Railyard Fuel Pumping Station (RFPS)
- Site 6 - Nondestructive Inspection Laboratory (NDI)

On 10 June 1983 WESTON conducted a Phase II Presurvey Site Inspection. A seventh site, referred to as the Petrol Fuel Storage Area (PFSA), was visited at this time. This additional unranked site is shown on Figure S-1, along with the other sites investigated in the Phase II study. A second site visit was made on 16 and 17 June 1983 to reinspect certain sites, review preliminary data, and

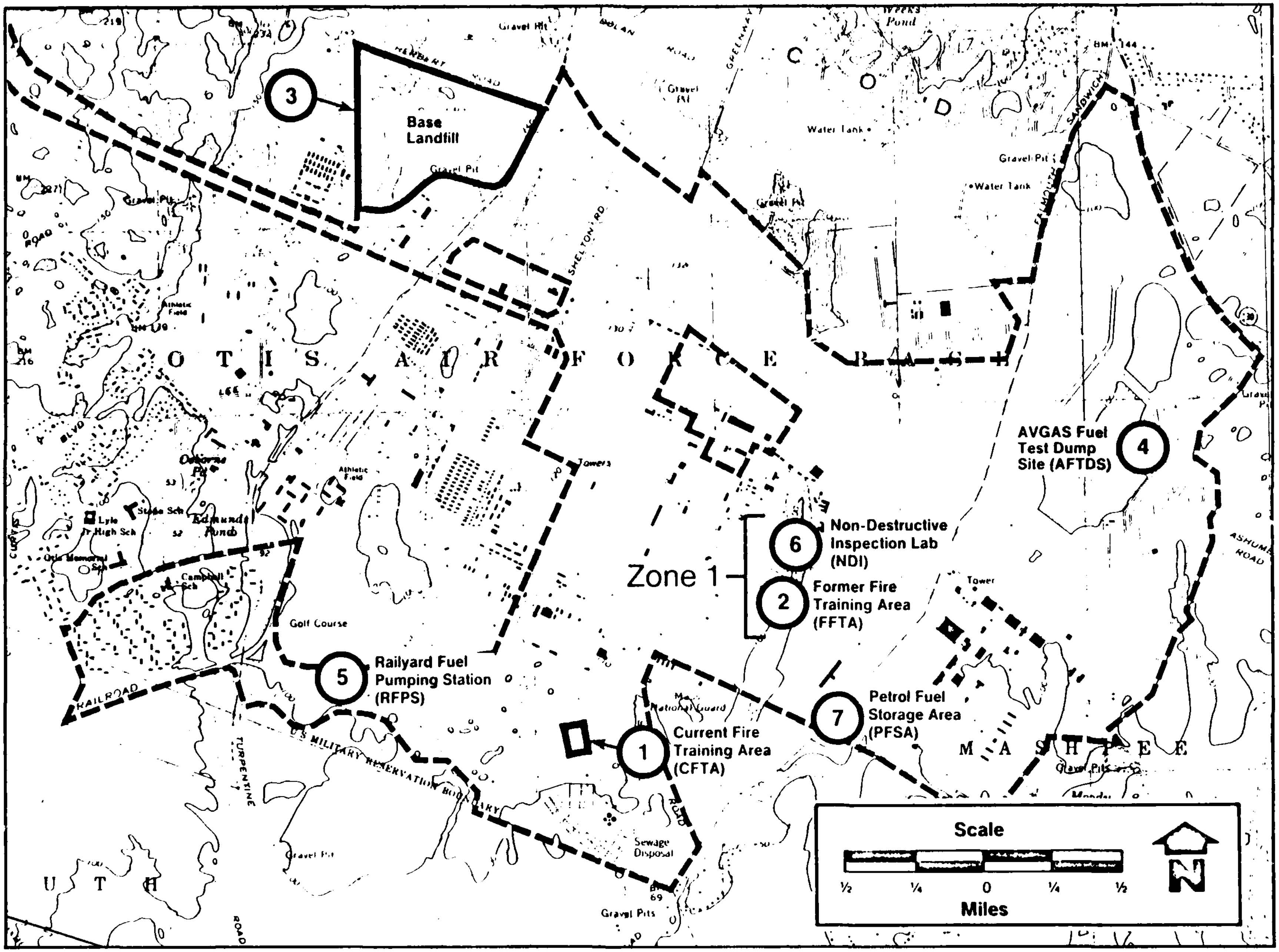

FIGURE S-1 LOCATION MAP OF PHASE II INVESTIGATION SITE AT OTIS AIR NATIONAL GUARD BASE

discuss alternative monitoring options. A presurvey report documenting WESTON's findings was prepared and submitted in July 1983.

Following a review of the Presurvey Report, Task Order 0028 dated 24 August 1983 was issued, authorizing a Phase II Problem Confirmation Study of three areas (including four individual sites). These have been defined as:

Site 1-	Current Fire Training Area (CFTA)
Zone 1- (Sites 2 and 6)	Former Fire Training Area and Non-Destructive Inspection Laboratory (FFTA/NDI)
Site 3	Base Landfill

A modification of the 24 August 1983 task order was subsequently authorized during the course of the investigation. A Phase II, Stage 1 Confirmation Report was deferred pending the completion of the supplemental work at three other sites of concern:

Site 4	Avgas Fuel Test Dump Site (AFTDS)
Site 5	Railyard Fuel Pumping Station (RFPS)
Site 7	Petrol Fuel Storage Area (PFSA)

In addition, a second round of analyses was approved for the wells already installed at Sites 1 and 3 and Zone 1 (Sites 2 and 6).

Field work was conducted in late 1983 and late 1984. Included in the fieldwork were drilling and construction of 13 monitor wells (including two replacement wells), test pit investigations at six of the seven sites (including collection and analysis of soil samples), and two rounds of groundwater sampling (one including only 7 wells, the other including all 13); sampling of sludge and liquid supernatants from a sump tank at the NDI; and sampling of waste oils from two header pipes at the RFPS.

MAJOR FINDINGS

The conclusions outlined in this section are based on an analysis of the geologic and hydrogeologic conditions en-

countered at Otis ANGB, as well as analytical results from soil samples (Tables 4-1 and 4-1-1), field tests (Tables 3-6 and 3-6-1), two rounds of sampling conducted at RFW-1 through RFW-7 and a single round of sampling conducted at RFW-8 through RFW-11 (Table 4-2).

Based on the Phase II, Stage 1 Confirmation study, the following conclusions have been reached:

1. The geologic setting at Otis ANGB consists of 200 to 300 feet of medium to coarse sands and gravels of glacial outwash origin. The sands reportedly become finer with depth (below 200 feet). The sands unconformably overlie crystalline basement rocks at depths exceeding 250 feet.

2. Groundwater occurs under unconfined or water table conditions in highly permeable, homogeneous sands and gravels underlying all sites investigated in this study. Groundwater flow in these deposits occurs generally in a southerly direction although there is a mild groundwater divide crossing the Base so that flow diverges either to the southwest or the southeast. This conclusion is based on the water level measurements made in the monitor wells completed for this study.

   Hydraulic conductivities of 200 to 300 feet per day have been estimated by others (LeBlanc 1982). These estimates seem reasonable in light of the soil and sediment conditions encountered during this investigation (see Boring Logs, Appendix D) and the indications of high permeability yielded by the in situ permeability testing conducted on the monitor wells during development.

3. Groundwater flows under a relatively low hydraulic gradient of between 0.001 and 0.002. Due primarily to the high permeability of the underlying sands and gravels, average linear velocities on the order of 1 to 2 feet per day have been calculated. This indicates that constituents in the groundwater may migrate on the order of 300 to 700 feet per year.

4. Groundwater generally occurs between 40 and 80 feet below land surface at Otis ANGB. The depth

to the regional water table increases to the northwest and was found to be deepest in the vicinity of the Base Landfill. Otis ANGB comprises a portion of the groundwater recharge zone for the Falmouth area south of Otis ANGB.

Due to the great depth to the water table, perennial surface streams do not occur at Otis ANGB. Any runoff swales or seasonal surface water flows at Otis ANGB are influent; that is, they discharge to the deeper groundwater flow system. Several deep ponds or kettle holes on or near Otis ANGB (Figures 2-4 and 4-3) are hydraulically connected to the regional aquifer and reflect the surface of the regional water table.

5. From the above findings, it is concluded that the groundwater flow system underlying Otis ANGB constitutes a valuable, high-yielding aquifer. By virtue of the sandy overlying deposits, it is susceptible to contamination not only from point sources at land surface but also from nonpoint discharges through influent streams. It is also concluded that a certain buffering capacity exists to mitigate potential contamination from surface activities. One factor affecting the mitigating potential is the thickness of the vadose zone (unsaturated zone above the water table) which can exhibit retentive or attenuative properties for certain potential contaminants including hydrocarbons. A second factor is the productivity of the aquifer, resulting in a significant dilution capacity to reduce the impact of potential contaminants generated by surface activities and migrating through the vadose zone to the water table.

6. A comparison of water quality criteria standards and guidance criteria for various analytes of concern with the values obtained in samples from monitor wells in this study indicates that groundwater sampled in the monitor wells generally meets both regulated standards and guidance criteria for water quality.

7. No evidence of groundwater pollution suggesting significant adverse health effects was noted in

any of the monitor wells. Wells RFW-1, RFW-2A, and RFW-4 at the Base Landfill, wells RFW-5 and RFW-6 at the Current Fire Training Area, well RFW-9 at the Railyard Fuel Pumping Station and well RFW-10 at the Petrol Fuel Storage Area were concluded to be slightly impacted by former or present operations or disposal activities. For example, monitor wells RFW-2A (Base Landfill) and wells RFW-5 and RFW-6 (Current Fire Training Area) contained tetrachloroethylene at levels ranging between 3.0 and 7.1 ug/L. These concentrations are above the 0.8 µg/L guidance criterion established for a 10^{-6} cancer risk for lifetime consumption ("Water Quality Criteria Documents", Federal Register, 28 November 1980). However, they are well within the 40 ug/L lifetime "Suggested No Adverse Response Level" or SNARL used by the EPA for assessing the severity of organic contamination of a drinking water source (EPA memo, 20 August 1981). This is discussed further in Section 4.3 of this report. It should be noted that the conclusions in this report regarding the significance of organic contamination by priority pollutant compounds is based on federal guidance criteria and not on established limits or regulated organic priority pollutant standards of which there are none for Massachusetts or the EPA at this time.

8. With the exception of copper, which was well within Federal Drinking Water Standards, priority pollutant metals were not detected in any of the landfill monitor wells, nor were cyanide, pesticides or PCB's. This indicates that the Base Landfill is not posing a significant threat to water resources based on these priority pollutant compounds.

9. The Current and Former Fire Training Areas, the Avgas Fuel Test Dump Site and the Railyard Fuel Pumping Station, monitored by RFW-5, RFW-6, RFW-7, RFW-8, RFW-9, and RFW-11 are not adversely impacting area water resources based upon the monitoring performed. Significant impacts would have been detected by IR Scans, GC/FID hydrocarbon scans, or the volatile organic analyses performed on groundwater samples from these wells. RFW-7,

which also serves as a remote monitor well for the NDI lab, did not reveal evidence of contamination from that former facility.

10. The sump tank at the NDI lab contains sludges which have not been classified as to their hazard. Although downgradient monitoring has not detected adverse environmental impacts from this facility, the contents of the sump tank warrant determination.

11. RFW-10, which is located downgradient of the Petrol Fuel Storage Area, exhibited xylenes and ethyl benzene within EPA health-related guidance criteria for drinking water. Further, fuel odors detectable on the HNu (12 parts per million above background) were measured in a soil/water sample collected during the drilling of well RFW-10. Although the contaminant levels noted in RFW-10 do not represent an imminent adverse health threat, their presence warrants further investigation at and beyond the potential source of contamination.

RECOMMENDATIONS

The findings of the Phase II, Stage 1 Problem Confirmation Study at seven sites, including one unranked site (PFSA), at Otis ANGB indicate that groundwater quality downgradient from the sites has not been significantly impacted by past activities. The Former Fire Training Area/Non-Destructive Inspection Laboratory and the Avgas Fuel Test Dump Site do not require additional evaluation because results of this study indicate they have not contributed to groundwater contamination. Follow-up IRP activities are recommended to address the results of this study and to expand the data base for evaluation of any remedial actions that might be necessary. In addition, it is recommended that closure actions be instituted at three sites where bulk storage of potentially hazardous wastes poses a potential future threat to the environment. Thus, the recommendations resulting from this study can be divided into three categories:

1. Preparation of an on-site well inventory.

2. Closure actions at the CFTA buried tanks, the NDI sump tank, and the RFPS header pipes and transmission lines.

3. Expansion of the water quality monitoring network at the CFTA, Base Landfill, and PFSA sites.

A short discussion of each recommendation is provided below. The recommendation, site affected, and rationale for for follow-on work are summarized in Table S-1.

WELL INVENTORY

A well inventory of all existing Base wells is recommended to provide a comprehensive data base for further site hydrogeologic analyses. These wells may provide future water quality or hydrologic information pertinent to the findings of this report and the sites which have been identified for further study.

CLOSURE ACTIONS

Closure actions are recommended for the two buried tanks at the CFTA, the NDI sump tank, and the RFPS header pipes and transmission lines. Although no significant groundwater contamination or environmental degradation has been detected at any of these former facilities, the presence of wastes under unsecured conditions poses a potential future threat to the environment. The recommended actions include annual sampling of groundwater monitoring wells for those facilities involved in closure actions.

EXPANSION OF WATER QUALITY MONITORING NETWORK

Two additional wells are proposed for the Current Fire Training Area at the locations shown in Figure 6-1. These wells will provide more comprehensive coverage of the site in terms of water quality and local flow information. The wells should be drilled approximately 20 feet into the seasonal low water table and be screened a short distance above the water table to detect the presence, if any, of floating hydrocarbons.

Three additional wells should be drilled at the the Base Landfill. A well north of RFW-1 is needed to monitor flow from the northern portions of the landfill to the west. An upgradient well is needed to improve groundwater flow information and provide background water quality data. A remote downgradient well is recommended between the Base Landfill and Otis ANGB supply well G to determine potential migration of contaminants, if any, from the area of the Base Landfill toward the Base supply well. The wells should be screened in the upper 50 feet of saturated deposits.

Table S-1

RECOMMENDATIONS FOR FOLLOW-ON WORK
OTIS AIR NATIONAL GUARD BASE

Recommendation	Site	Rationale
1. Preparation of an On-Site Well Inventory	Inventory of all potable and non-potable wells, monitoring piezometers, or other groundwater sources on Base	To determine access and position for future sampling and monitoring both in terms of water quality and hydrologic data. Important relative to areal interpretations of ground-water flow and quality.
2. Closure Actions and Annual Water Quality Monitoring	CFTA buried tanks, NDI sump tank, and the RFPS header pipes and transmission lines	The presence of potentially hazardous wastes under unsecured conditions makes these sites continuing sources of potential contamination which could pose a future threat to the environment. These sites should be monitored while closure actions are determined.
3. Expansion of Water Monitoring Network	Current Fire Training Area, Base Landfill, Petrol Fuel Storage Area	Hydrogeologic findings in Stage 1 dictate a need for additional investigation and monitor points to be located at these sites.

Three additional monitor wells are recommended for the PFSA to define the presence of a floating hydrocarbon layer at the active facility. The wells should be constructed to penetrate the upper 20 feet of the zone of saturation and be screened above the seasonal high water table to detect floating hydrocarbons, if present. Surface waters in ponds south of the PFSA should also be sampled for the presence of hydrocarbons. Up to six surface water sampling locations are recommended. If there are any existing private wells off-Base in the vicinity of the Cranberry Bog south of the PFSA, they should be inventoried for future potential use as sampling points.

SECTION 1

INTRODUCTION

1.1 INSTALLATION RESTORATION PROGRAM

The purpose of the Installation Restoration Program (IRP) is to assess and control migration of environmental contamination that may have resulted from past operations and disposal practices at Department of Defense (DoD) facilities. In response to the Resource Conservation and Recovery Act of 1976 (RCRA) and in anticipation of the Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA or "Superfund"), the DoD issued a Defense Environmental Quality Program Policy Memorandum (DEQPPM) dated June 1980 (DEQPPM 80-6) requiring identification of past hazardous waste disposal sites on DoD agency installations. The U.S. Air Force implemented DEQPPM 80-6 in December 1980. The program was revised by DEQPPM 81-5 (December 1981) which reissued and amplified all previous directives and memoranda on the IRP. The Air Force implemented DEQPPM 81-5 in January 1982. The Installation Restoration Program has been developed as a four-phase program as follows:

- Phase I - Problem Identification/Records Search
- Phase II - Problem Confirmation and Quantification
- Phase III - Technology Base Development
- Phase IV - Corrective Action

Only the Phase II, Stage 1 Problem Confirmation portion of the IRP effort at Otis Air National Guard Base (Otis ANGB) was included in the effort described in this report. Definitions of the terms and acronyms used in this report are in Appendix A.

Otis Air National Guard Base is located on Cape Cod, approximately 60 miles south of Boston. The Base extends into the Towns of Falmouth, Bourne, Mashpee, and Sandwich. Figure 1-1 is an index map showing the location of Otis ANGB.

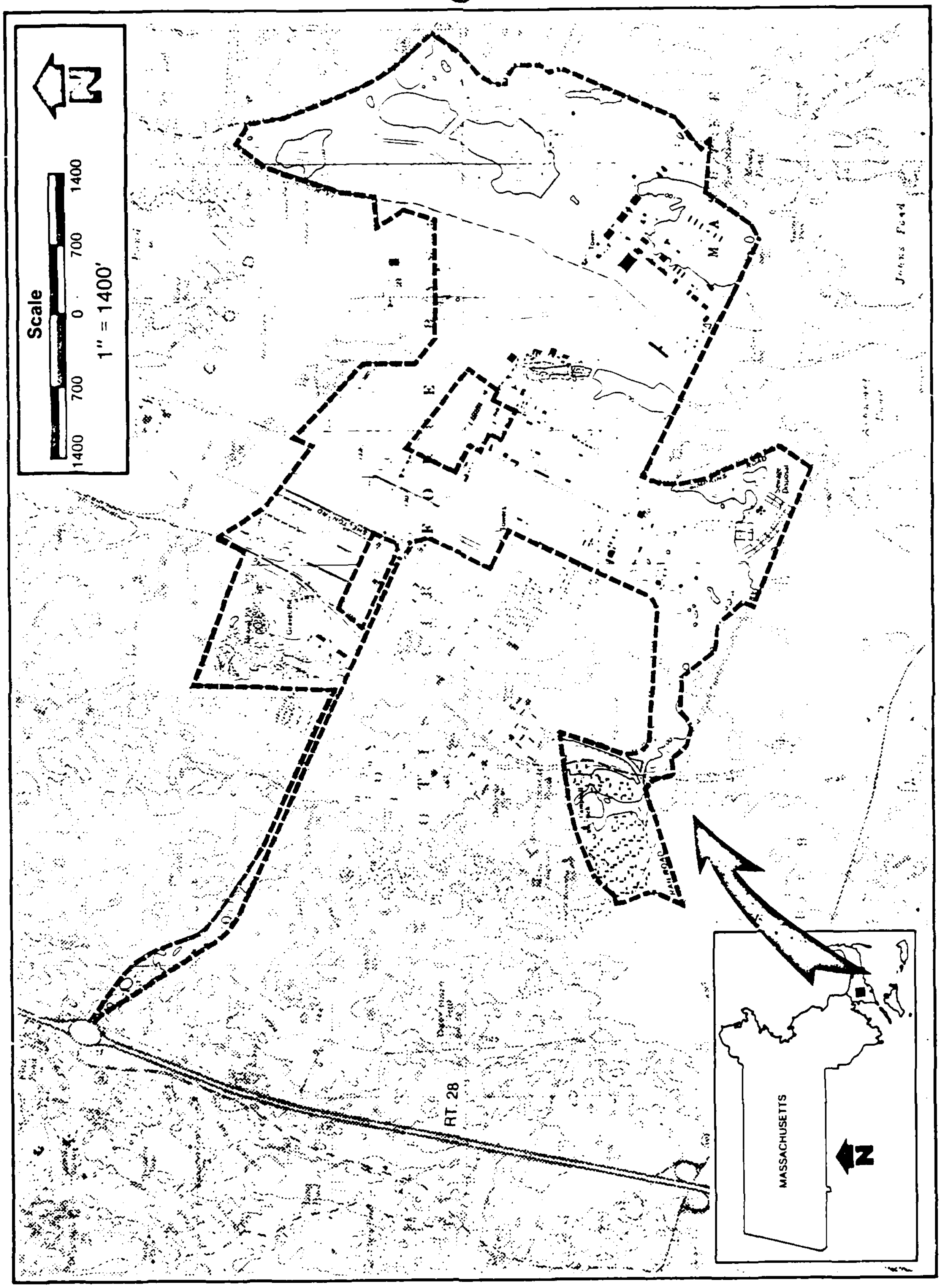

FIGURE 1-1 INDEX MAP SHOWING THE LOCATION OF OTIS AIR NATIONAL GUARD BASE

1.2 PROGRAM HISTORY AT Otis ANGB

Roy F. Weston, Inc. (WESTON) has been retained by the United States Air Force Occupational and Environmental Health Laboratory (USAF OEHL) under Basic Ordering Agreement (BOA) Contract Number F33165-80-D-4006 to provide the Air Force with general engineering, analytical, and hydrogeological services. The Phase I, Problem Identification/Records Search at the Otis Air National Guard Base was conducted by Metcalf & Eddy (M&E). The Phase I Final Report was submitted to USAF OEHL in January 1983. In response to the findings contained in the M&E Phase I Final Report, the USAF OEHL issued Task Order 0018 to WESTON, directing that a presurvey be conducted at Otis ANGB to obtain sufficient information to start a full Phase II, Problem Confirmation and Quantification Study at Otis ANGB.

1.2.1 Phase I Report

The Phase I report prioritized six potential problem areas as a basis for the Phase II, Stage 1 Problem Confirmation Study. The six sites shown on Figure 1-2 are:

- Site 1 - Current Fire Training Area (CFTA)
- Site 2 - Former Fire Training Area (FFTA)
- Site 3 - Base Landfill
- Site 4 - Avgas Fuel Test Dump Site (AFTDS)
- Site 5 - Railyard Fuel Pumping Station (RFPS)
- Site 6 - Nondestructive Inspection Laboratory (NDI)

Each site was initially assessed by M&E using the Hazardous Assessment Rating Methodology (HARM). The sites were ranked based on four aspects of the potential hazard: possible receptors of the contaminant; waste characteristics and quantity; potential pathways for contamination migration; and waste management practices. The preliminary rankings were later reassessed by WESTON using field data obtained during the Phase II Presurvey Site Inspection.

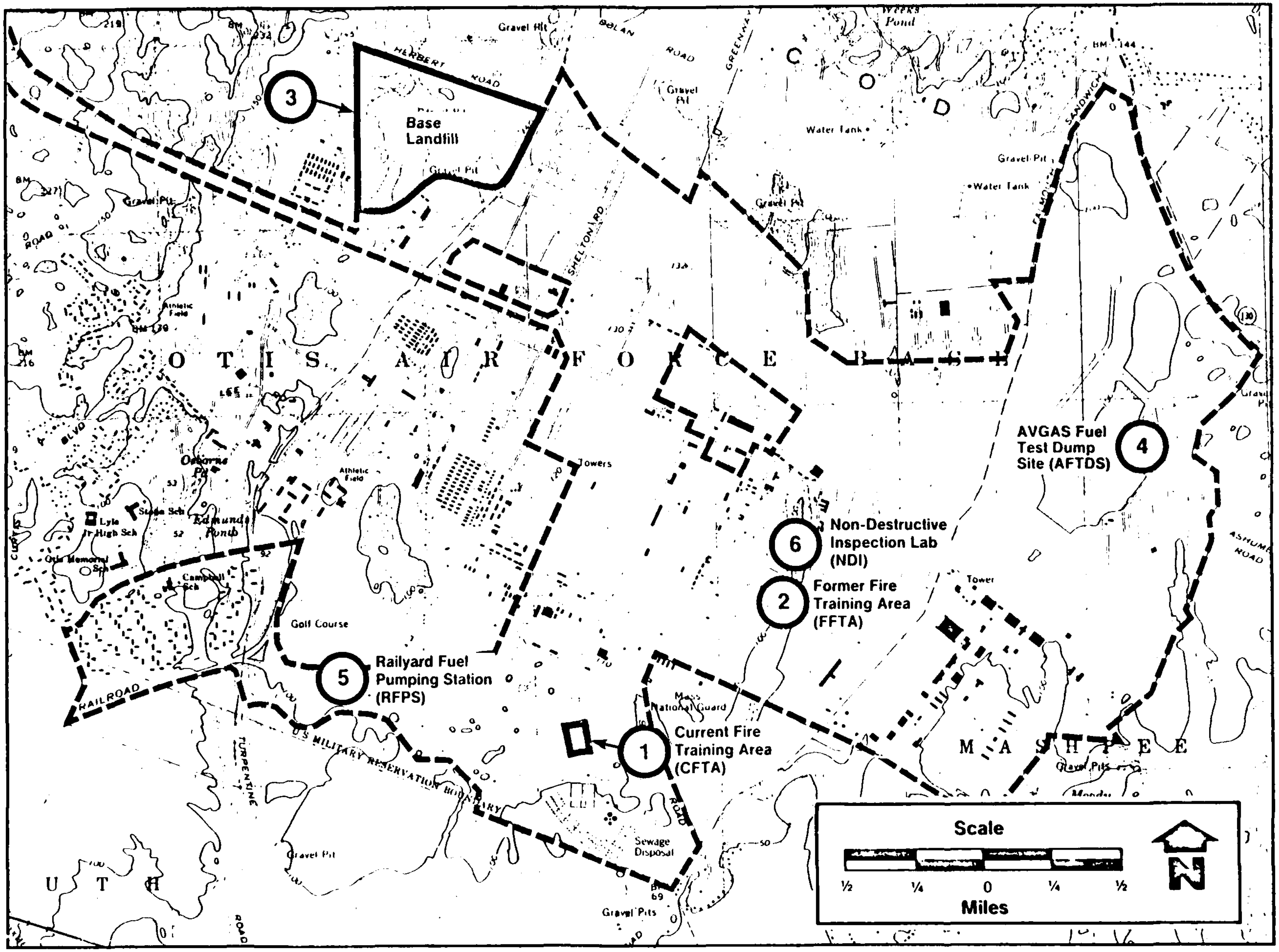

FIGURE 1-2 MAP OF OTIS AIR NATIONAL GUARD BASE SHOWING SITES RECEIVING HARM SCORE RATINGS IN PHASE I

The Hazardous Assessment Rating Methodology scores and rankings for the six sites are listed in Table 1-1. According to findings of the Phase I Report, the major potential environmental impacts are associated with solvent, waste oil, and fuel use in the current and former fire training areas and long-term disposal (40+ years) operations at the Base Landfill which periodically received fuel tank sludges, solvents, transformer oils, paints, batteries, and small quantities of herbicides, among other debris possibly containing hazardous substances.

1.2.2 Phase II Presurvey

On 10 June 1983 two WESTON hydrogeologists conducted a Phase II Presurvey Site Inspection. Also present at this time were representatives of Otis ANGB, as well as officials from the Air National Guard Support Center (ANGSC/DEV and ANGSC/SG) from Andrews Air Force Base. On 10 June, a seventh site, referred to as the Petrol Fuel Storage Area (PFSA), was also visited. This additional unranked site is shown on Figure 1-3, along with the other sites investigated in the Phase II study. The purpose of the Phase II presurvey was to obtain sufficient information to develop a full Phase II, Stage 1 Problem Confirmation Study at Otis ANGB. A second site visit was made on 16 and 17 June 1983 to reinspect certain sites, review preliminary data, and discuss alternative monitoring options. A presurvey report documenting WESTON's findings was prepared and submitted in July 1983.

1.2.3 Phase II, Stage 1 Problem Confirmation Study

Following review of the Presurvey Report, Task Order 0028 dated 24 August 1983 was issued, authorizing a Phase II Problem Confirmation Study of three areas (including four individual sites). These have been defined as:

Site 1-	Current Fire Training Area (CFTA)
Zone 1- (Sites 2 & 6)	Former Fire Training Area and Non-Destructive Inspection Laboratory (FFTA/NDI)
Site 3	Base Landfill

TABLE 1-1 Summary of Harm Scores for Potential Contamination Sources[1]

Site Rank	Site Name	Receptor Subscore	Waste Characteristics Subscore	Pathways Subscore	Waste Management Factor	Overall Total Score
1	Current Fire Training Area (CFTA)	62	100	80	1	81
2	Former Fire Training Area (FFTA)	66	100	61	1	76
3	Base Landfill	66	75	80	1	74
4	Avgas Fuel Test Dump Site (AFTDS)	66	100	46	1	71
5	Railyard Fuel Pumping Station (RFPS)	64	100	46	1	70
6	Non Destructive Test Lab (NDI)	66	60	61	1	62

(1) Source: M&E, 1983

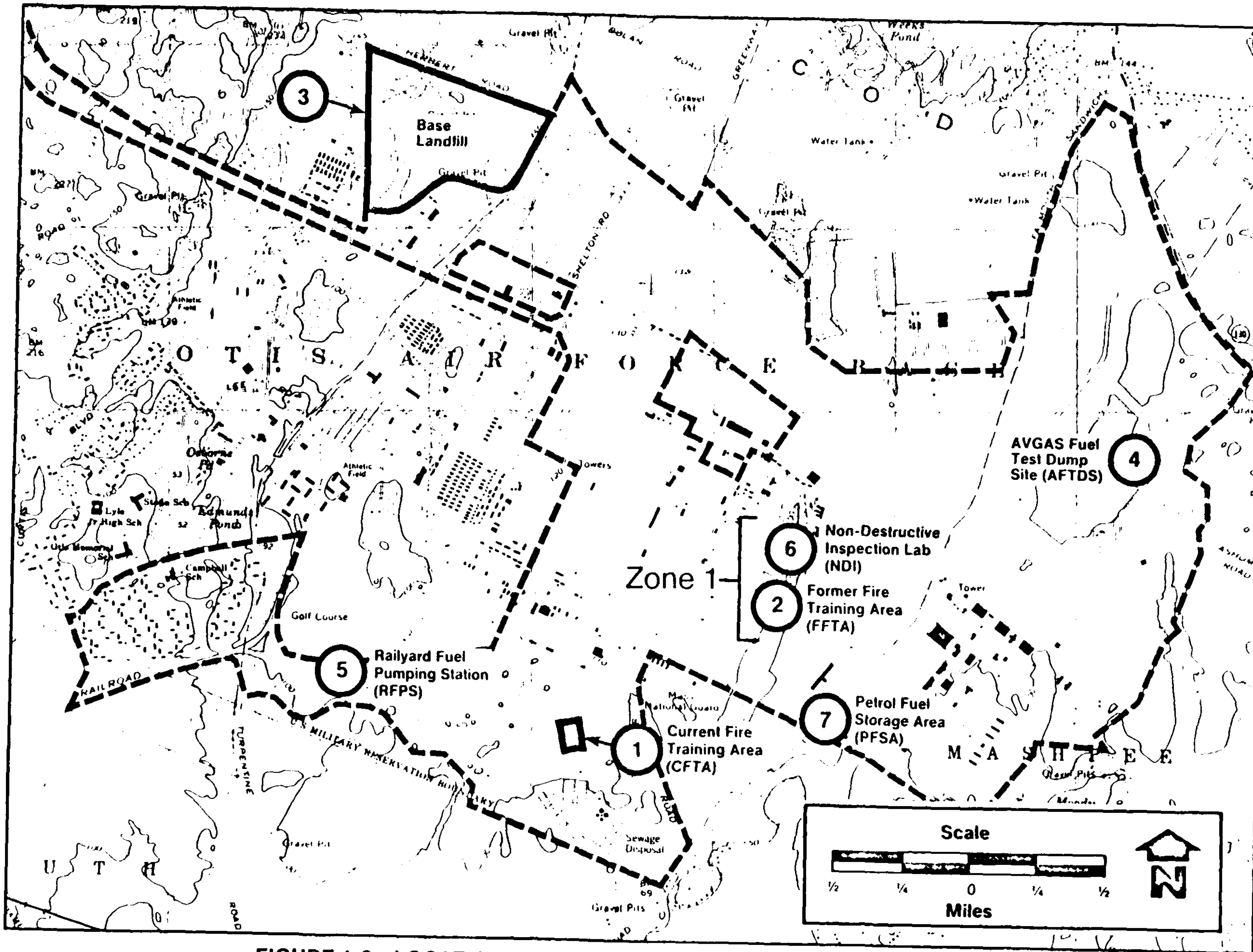

FIGURE 1-3 LOCATION MAP OF PHASE II INVESTIGATION SITE AT OTIS AIR NATIONAL GUARD BASE

A modification of the 24 August 1983 task order was subsequently authorized during the course of the investigation. A Phase II, Stage 1 Confirmation Report was deferred pending the completion of the supplemental work at three other sites of concern:

Site 4 Avgas Fuel Test Dump Site (AFTDS)

Site 5 Railyard Fuel Pumping Station (RFPS)

Site 7 Petrol Fuel Storage Area (PFSA)

All sites selected for the Phase II study are shown on Figure 1-3. In addition, a second round of analyses was approved for the wells already installed at Sites 1 and 3 and Zone 1 (Sites 2 and 6).

A copy of the formal task order and scope of work are included in Appendix B. The modifications are highlighted by underlining. A pre-performance meeting was held on 25 October 1983 with representatives of Otis ANGB, WESTON, Air National Guard Support Center and the selected subcontract drillers, D. L. Maher Company of North Reading, Massachusetts.

1.2.3.1 Initial Investigations - Sites 1, 2, 6 and 3

As part of the initial investigation, exploratory test pit excavation and soil sampling commenced on 30 November and was completed by 1 December 1983. The exploratory drilling and monitor well construction program began on 6 December and was completed by 30 January 1984. Eleven monitor wells were installed at this time. During the week of 6 February 1984 all sampling and field survey work was completed. A resampling of the supernatant from the septic tank at the NDI laboratory was performed on 23 February 1984 due to breakage of the first round of total organic halogen (TOX) samples.

1.2.3.2 Supplemental Investigation - Sites 4, 5 and 7

In September 1984, formal authorization was given to proceed with the supplemental work. Exploratory test pits and soil sampling were conducted at the Railyard Fuel Pumping Station (RFPS) and the Avgas Fuel Test Dump Site (AFTDS) on 1 and 2 October 1984. Four additional wells were installed at these

two sites and downgradient of the Petrol Fuel Storage Area (PFSA) between 9 and 18 October 1984. All wells were sampled during the week of 5 November 1984. On 13 December 1984 two samples were collected from Headers 7 and 12 at the off-loading rack of the Railyard Fuel Pumping Station. Otis ANGB personnel collected samples of Mogas, Avgas, JP-4, diesel fuel, and heating oil for comparative analysis with the products collected at the header pipes. All supplementary field and survey work was completed by 13 December 1984.

Resampling for selected parameters was conducted in April and July, 1985. The resampling was conducted when holding times for selected analytes were exceeded and when anomalous results for total organic carbon and priority pollutant organics were obtained during the initial analysis.

1.3 BASE PROFILE

The base covers 3230 acres, including easements, of which 33 percent is owned by the U.S. Air Force. The remainder is owned by the Commonwealth of Massachusetts and is leased to the U.S. Air Force. Camp Edwards, operated by the Army National Guard, and a U.S. Coast Guard Air Station are contiguous to Otis ANGB. Properties abutting the Base include:

- North - Camp Edwards, located in the Towns of Bourne and Sandwich
- West - Camp Edwards and the U.S.Veterans Administration National Cemetery in the Town of Bourne
- South - Rural areas of Falmouth and Mashpee
- East - Rural areas of Mashpee

An historical chronology of the Base is outlined in Table 1-2. Since development of the Base in 1935, various hazardous materials have been used and/or disposed at various locations on the Base. Seven sites have been identified for Phase II investigation, and a brief history of each is given below. A data summary for the seven sites is provided in Table 1-3.

TABLE 1-2

Historical Chronology of Otis Air National Guard Base [1]

1935	Massachusetts Legislature passes bill to purchase present site to train Massachusetts National Guard (MNG)
1935-40	WPA workers construct camp known as Otis Field which included two 500 foot wide turfed runways on 79 acres of land. Runways were 3630 and 3890 feet in length, and were used to train the 101st Observation Squadron of the MNG.
1940	U.S. Army leased land including Otis Field from the Commonwealth of Massachusetts and constructed Camp Edwards as a troop training center.
1941	Dormitories, support facilities, and 1722 bed hospital added.
1944	Facility turned over to the U.S. Department of the Navy for remainder of National Emergency.
1948	U.S. Air Force assumed control of Otis Field and 68.5 approach acres, and runway 05/23 extended from 7000 to 8000 ft.
1952	Portions of Camp Edwards acquired by Otis under Public Law 155.
1954	Massachusetts Air National Guard Permanent Field Training Site (PFTS) established and manned by 35 people. Primary mission to support training operations.
1955	551st Early Warning and Control Wing (AEWC) and 60th Fighter Interceptor Squadron added to Base.
1956	USAF negotiated 99 year lease with Commonwealth of Massachusetts for 19700 acres of land including Otis Field and Camp Edwards, adding runway space, a control tower, fire station, hangars, nose docks and an 1193 unit family housing area.
1962	26th Air Defense Missile Squadron activated.
1968	102nd Tactical Fighter Wing (MANG) arrived.
1970	4713th Defense Systems Evaluation Squadron was added after 551st AEWC deactivated. U.S. Coast Guard commissioned CG Air Station, Cape Cod.
1972	PFTS deactivated.
1973	4784th Air Base Group deactivated and USAF discontinued use of Otis Air Force Base and 3230 acres became Otis Air National Guard Base.

[1] Source: M&E (1983), p. 2-1 through 2-7.

Table 1-3

Data Summary of Potential Contamination Sources(1)

Site Name	Waste Material (quantity)	Period of Use
Current Fire Training Area (CFTA)	JP-4 (currently 3000 gal/yr not consumed in fires), avgas, waste engine oil, transformer oil (2 drums), solvents, etc. (>100 drums)	1958 - Present
Former Fire Training Area (FFTA)	Avgas and waste engine oil, (assume 3000 gal/yr), solvents	1950(?) - 1958 1950(?) - 1958
Base Landfill	General refuse, herbicides (8 drums or more), transformer oil (small amount), hydraulic fluid, batteries, formaldehyde (2-3 pallets), solvents, blank small arms ammunition, paints, DDT powder, hospital materials (8 truckloads), fuel tank sludges (assume >100 drums of misc. wastes)	1940 - Present
Avgas Fuel Test Dump Site (AFTDS)	Avgas (assume 50,000 gal. or more)	1955 - 1970
Railyard Fuel Pumping Station (RFPS)	Avgas, JP-4 (assume 10,000 gal. or more)	1959 - 1965
Non-Destructive Inspection Lab	Solvents, penetrant, emulsifier, developer (assume 450 gal/yr)	1955 - 1970
Petrol Fuel Storage Area (PFSA)	Fuel Products: Avgas, mogas, JP-4, heating oil	1974 - Present

(1) Source: M&E (1983), except for Petrol Fuel Storage Area

1.3.1 History and Description of Site 1, Current Fire Training Area (CFTA)

According to the Phase I report, the CFTA has been in active use since approximately 1958. The site location and surrounding features are depicted on Figure 1-4. Prior to the 1980's, the fire training area was unlined. Fires were created by burning fuels or waste oil; however, other materials such as solvents, paint thinners, transformer oils, and hydraulic fluids were also reported to have been burned there. Unconsumed waste, as well as the firefighting chemicals, were allowed to evaporate or infiltrate the soils.

Prior to the 1970's, monthly fire training exercises were held at the CFTA. Since then, the frequency has been reduced to quarterly. Eight days of training typically occur in a quarter. Based on the particular exercise, either 50 or 300 gallons of fuel are used for each burn. In recent years, approximately 7,000 to 10,000 gallons of jet fuel have been allocated on an annual basis (Phase I report). According to Base personnel, 70 per cent of the fuel is consumed in the fires. Estimates of fuel and waste volumes used in burns preceding the 1980's was unavailable.

A pumping well installed downgradient of the CFTA by the Woods Hole Oceanographic Institute for use in a spray irrigation project, was reportedly abandoned when hydrocarbon odors were noted in the water.

1.3.2 History and Description of Site 2, Former Fire Training Area (FFTA) and Site 6, Nondestructive Inspection Laboratory (NDI)

Prior to 1958, the FFTA was used to train Base firefighting personnel. Moderate to large quantities of waste oils and contaminated fuel, as well as drums of various other flammable fluids, were burned at the site over a period of approximately 6 to 8 years (M&E, 1983). An estimated 3,000 gallons per year of Avgas, waste engine oil, and solvents were burned at this site on an annual basis. The precise location of the FFTA was not identified in the Phase I report. Based on interviews, the site was unlined and was located in a drainageway in the approximate area shown on Figure 1-5.

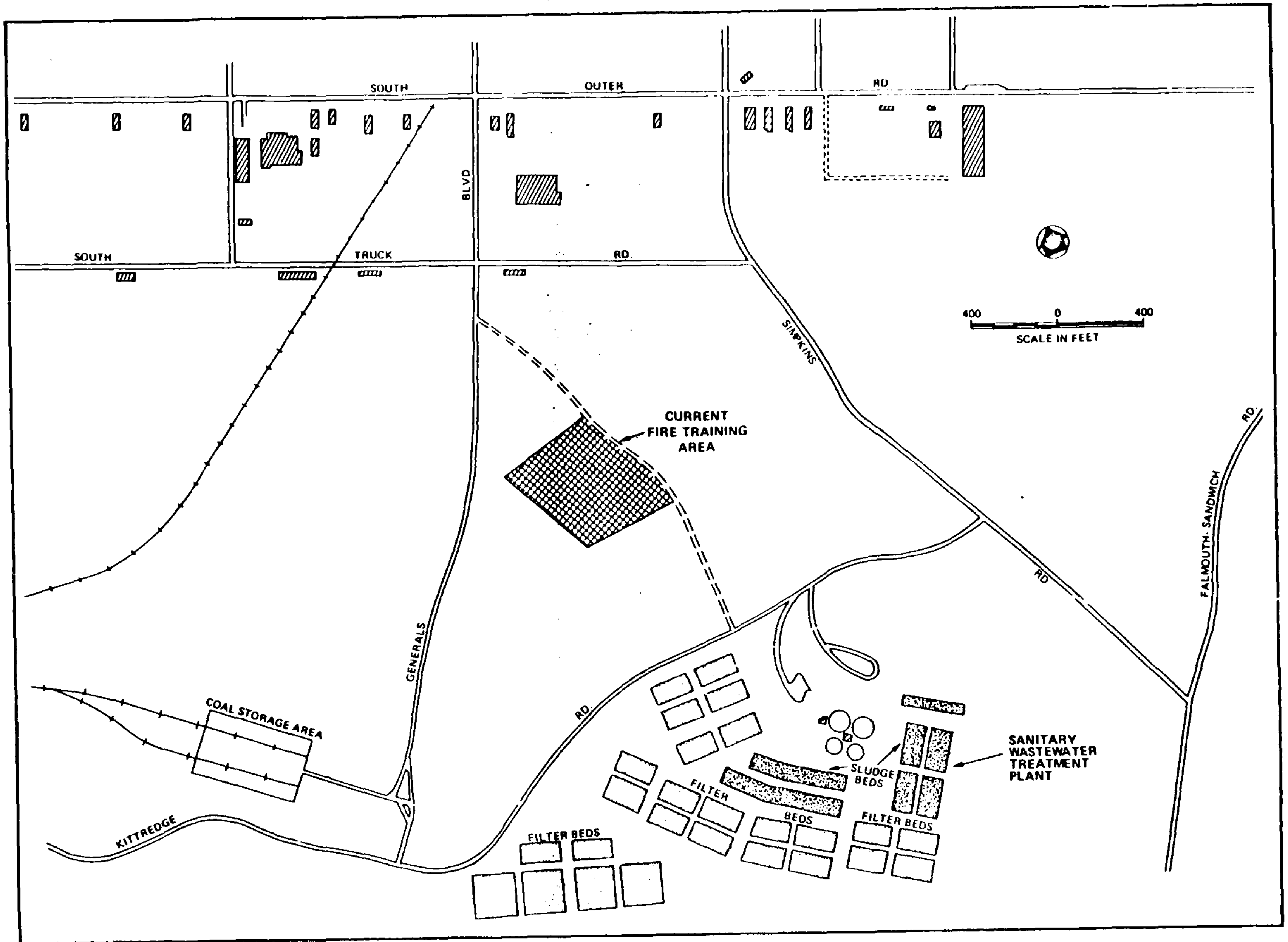

FIGURE 1-4 SITE MAP FOR THE CURRENT FIRE TRAINING AREA

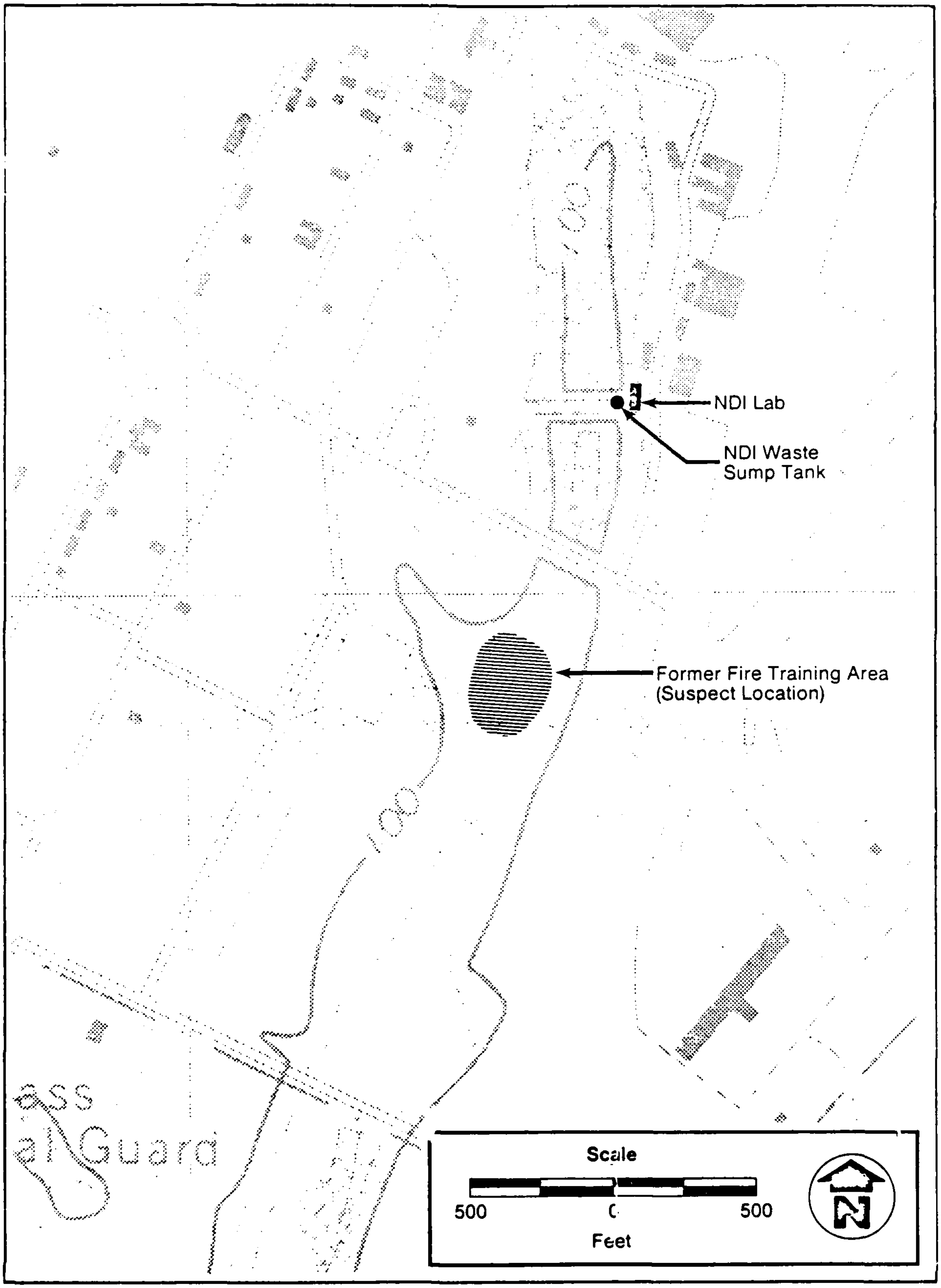

FIGURE 1-5 SITE MAP FOR THE NON-DESTRUCTIVE INSPECTION LABORATORY AND THE FORMER FIRE TRAINING AREA

A Nondestructive Inspection Laboratory (NDI) was located near the FFTA in Building 3146 from approximately 1965 to 1978. An on-site leaching pit, referred to as the sump tank, was a suspected disposal point for waste trichloroethylene and other halogenated solvents used in the NDI. Reportedly, penetrants, emulsifiers, and developers were also dumped there. This site is also illustrated in Figure 1-5.

1.3.3 History and Description of Site 3, Base Landfill

The sanitary landfill at Otis ANGB (Base Landfill) covers approximately 100 acres and is situated in the northwest corner of Otis ANGB. Figure 1-6 illustrates the approximate location of the Base Landfill as delineated in the Phase I report. According to the Phase I study, the landfill has been in use since 1940, and unrestricted dumping occurred until the Air National Guard assumed responsibility for its operation on 1 October 1980.

Waste materials allegedly disposed of on-site included: general refuse, fuel tank sludges, herbicides, solvents, transformer oil, fire extinguisher fluids, blank small arms ammunition, paints, batteries, DDT powder, and hospital materials (M&E, 1983). To date, approximately 60 to 70 acres of the site have been covered to varying depths.

Since 1980, a guard has been posted at the landfill entrance off Herbert Road and restrictions have been placed on the types of waste disposed on-site. Currently, wastes are placed in trenches and covered daily with coarse-grained sands and gravels excavated from the trenches. The Phase I report indicates that similar methods were used in the past. The trenches are reportedly about 30 feet deep, 50 feet wide, and up to 500 feet in length. The landfill surface is relatively flat to gently sloping, with elevation changes of up to 15 to 20 feet in areas where sand and gravel have been excavated.

1.3.4 History and Description of Site 4, Avgas Fuel Test Dump Site (AFTDS)

During the period when EC-121 aircraft (Constellations) were operating at Otis ANGB (1955 through early 1970's), a remote site was used to test fuel dump valves. The site is located on a parking apron which reportedly was surrounded on three sides by embankments of sandy and gravelly soils (M&E,

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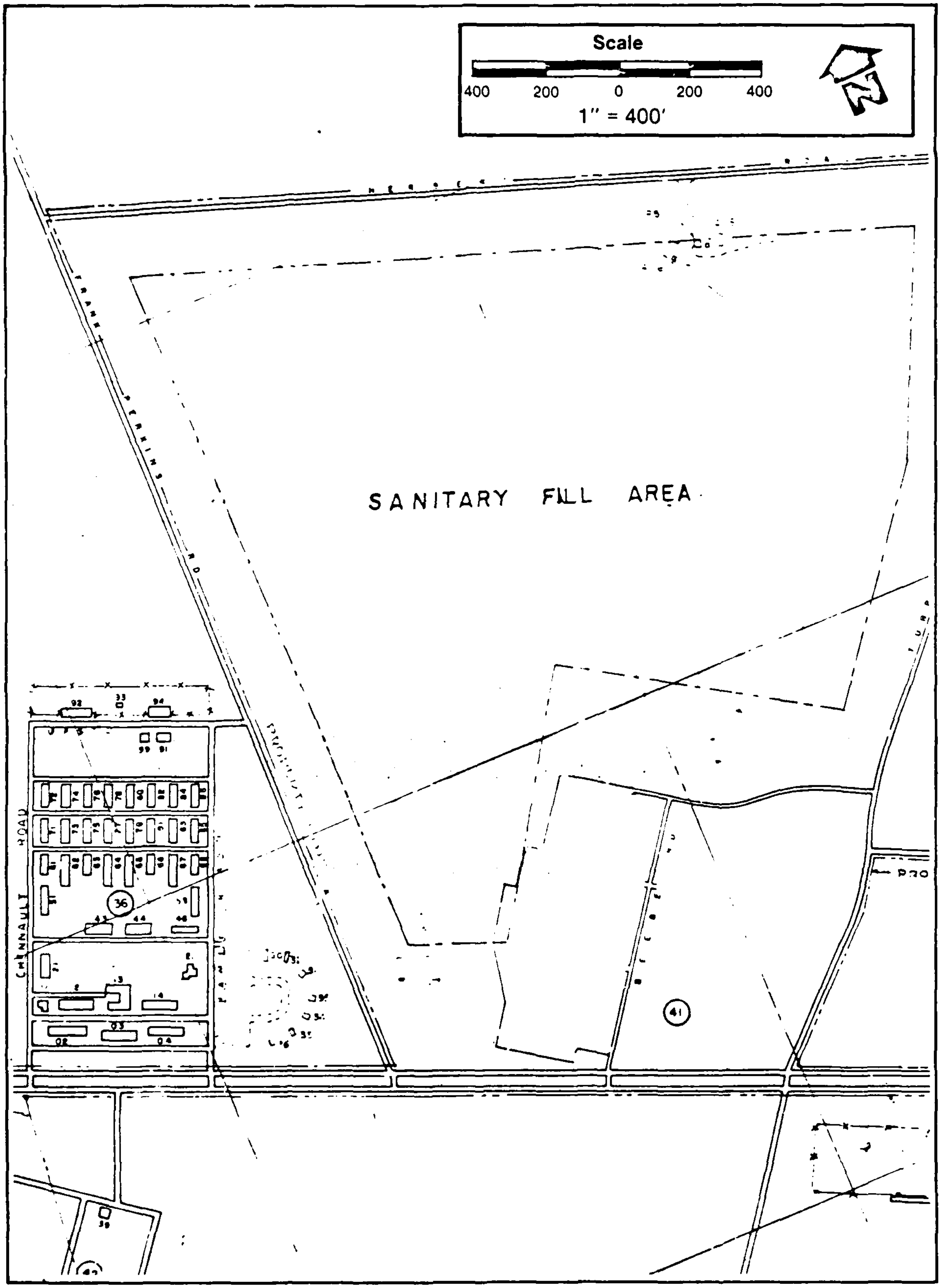

FIGURE 1-6 SITE MAP FOR BASE LANDFILL

1983). The site location is illustrated on Figure 1-7. The Constellations were towed to the site; six manually operated fuel dumping valves were then opened for testing. An estimated 100 to 500 gallons of Avgas were dumped during each aircraft test. According to the Phase I report, tests were conducted two to three times per week during the late 1960's and early 1970's. A firefighting crew would wash the Avgas into the soils around the pavement to reduce fuel vapors in the area. Barrels were later used to catch and contain dumped fuel. Estimates have been made that up to 50,000 gallons of Avgas could have been dumped in a five year period. However, no complete inventory of product discharge is available.

The AFTDS is presently a flat open area with a sand and gravel hillside embankment to the south. A southeast trending drainage swale is located west of the site. The site is surrounded by scrub brush and dwarf pine. There was no direct evidence (such as soil staining) of fuel dumping in the area based on a site reconnaissance conducted in June 1983. Comparison of a 1941 topographic map with a recent (1979, photo-revised) topographic map indicates no significant change in site topographic conditions.

1.3.5 History and Description of Site 5, Railyard Fuel Pumping Station (RFPS)

Prior to 1965, fuel was delivered to a number of storage areas on Otis ANGB from a pipeline and pumping station located near the rail spur at the southern edge of the Base. The RFPS site is illustrated on Figure 1-8. Large quantities of Avgas and JP-4 were pumped from this site between 1959 and 1965. Product pumpage was most intense between 1959 and 1961. According to the Phase I report, large quantities of fuel were spilled in and around the rail spur during active operations. As much as 10,000 gallons of spillage has been estimated to have occurred at the RFPS (M&E, 1983).

1.3.6 History and Description of Site 7, Petrol Fuel Storage Area - Unranked (PFSA)

The location of the present Petrol Fuel Storage Area is shown in Figure 1-9. The PFSA consists of three above-ground storage tanks having capacities of 8,000, 14,000, and 22,500 barrels each. The 8,000 barrel storage tank was installed in the early 1950's to store JP-4. In

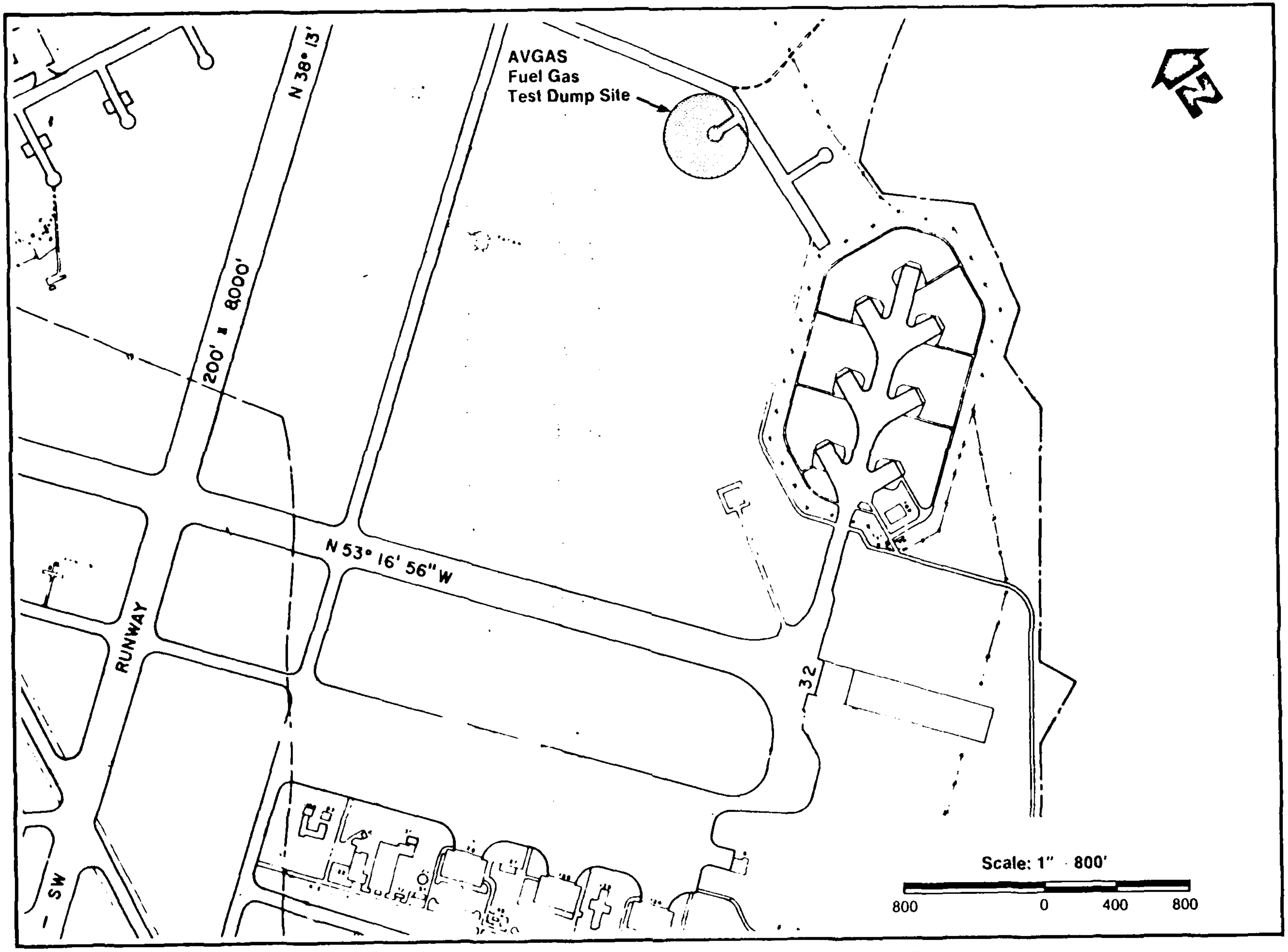

FIGURE 1-7 SITE MAP FOR AVGAS FUEL TEST DUMP SITE

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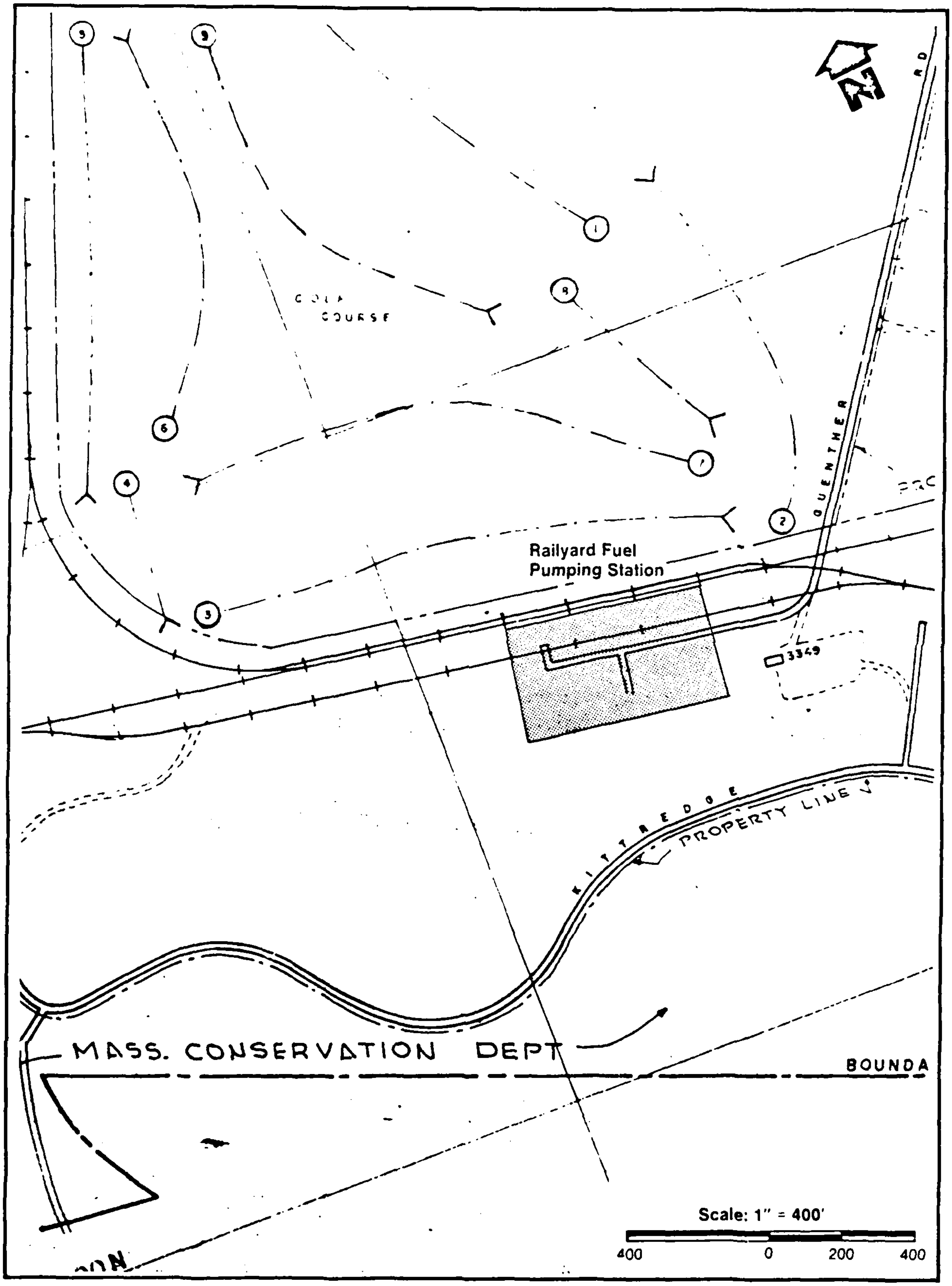

FIGURE 1-8 SITE MAP FOR RAILYARD FUEL PUMPING STATION

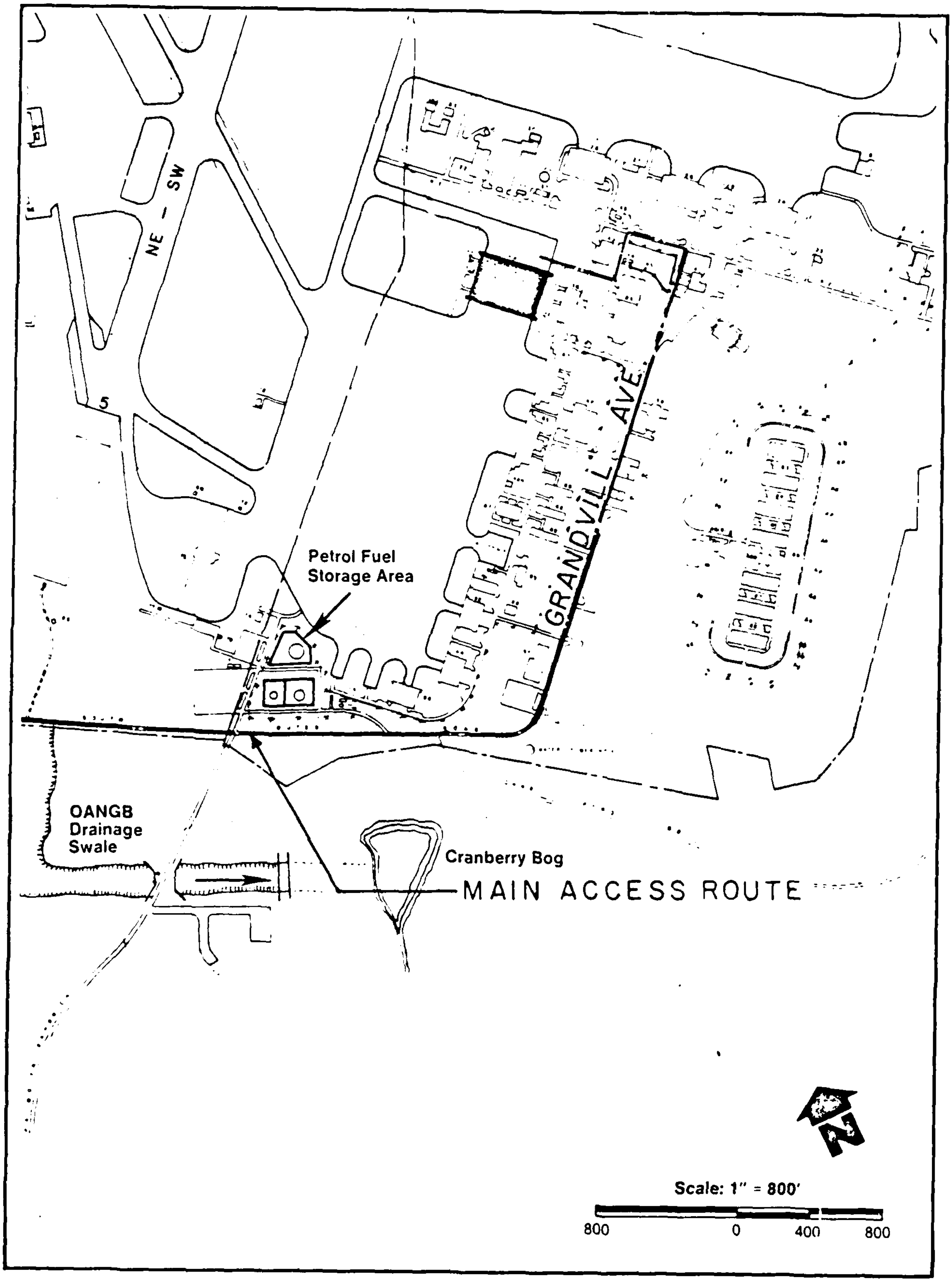

FIGURE 1-9 SITE MAP FOR PETROL FUEL STORAGE AREA

the middle 1950's, the 14,000 and 22,500 barrel tanks were constructed to hold JP-4 and Avgas, respectively. Since approximately 1973, the 8,000 barrel tank has held heating oil and the larger tanks both hold JP-4. Avgas is presently stored at other locations on Otis ANGB.

No specific volume losses have been confirmed, although one interviewee in the Phase I investigation reported spills of unknown volume at the PFSA. Due to the large volume of petrol product storage in this area and its position relative to the Base boundary, a monitor well was proposed for this unranked site.

1.4 CONTAMINATION PROFILE

The Base activities which have accounted for the generation of hazardous substances potentially affecting the environment are principally aircraft maintenance operations, firefighting training, fuels management and Base waste disposal operations. To a large extent the predominant sources of potential problems are fuels, fuel tank sludges, waste oils, and solvents. To a lesser extent the disposal of transformer oils possibly containing PCB's, herbicides, batteries, formaldehyde, blank small arms ammunition residues and hospital materials may have affected environmental quality, according to the Phase I Records Search.

Four of the ranked sites (Table 1-3) ceased operations prior to 1970 and, for approximately 14 years, have had no additional contributions of discharge or wastes. The exceptions to this are the Base Landfill, the Current Fire Training Area, and the unranked Petrol Fuel Storage Area.

To develop an initial determination of whether or not past disposal practices have adversely impacted the environment, the investigation at each site was matched to the nature of the potential contamination source. Based on the length of inactivity at the FFTA and NDI facilities, these two sites were combined for a zonal analysis. Soils were sampled at the CFTA, FFTA/NDI, RFPS and AFTDS; exploratory drilling was performed in each area of concern and groundwater was sampled from newly constructed wells downgradient of each site. In addition, the supernatant and sludge from the leachfield holding tank at the NDI facility and the waste oils in the header pipes at the former RFPS were sampled. A description of the work performed during the Phase II

Confirmation Study is presented in Section 3 of this report.

1.5 PROJECT TEAM

The Phase II Confirmation Study at Otis ANGB was conducted by WESTON personnel and managed through WESTON's Regional Office in Concord, New Hampshire. The following personnel served lead functions in this project. Appendix C contains Professional Profiles by key personnel.

1.5.1 WESTON Personnel

PETER J. MARKS, PROGRAM MANAGER:

Corporate Vice President, M.S. in Environmental Science, 18 years experience in laboratory analysis and applied environmental sciences.

FREDERICK BOPP, III, Ph.D., P.G., CONTRACT MANAGER

Manager of the Geosciences Department, Doctor of Philosophy (Ph.D.) in Geology and Geochemistry. Registered Professional Geologist (P.G.), over 8 years experience in hydrogeology and applied geological sciences.

RICHARD L. KRAYBILL, P.G., PROJECT MANAGER:

Regional Geologist for New England, M.S. in Geological Sciences, over 14 years experience in applied geology and hydrogeology.

DAVID WOODHOUSE, P.G., PROJECT GEOLOGIST:

Registered Professional Geologist, M.A. in Geological Sciences, over 18 years experience in applied and engineering geology and hydrogeology. Fieldwork conducted through January 1984.

WALTER M. LEIS, P.G., GEOTECHNICAL QUALITY ASSURANCE OFFICER:

Corporate Vice President, M.S. in Geological Sciences, Registered Professional Geologist, over 10 years experience in hydrogeology and applied geological sciences.

JAMES S. SMITH, Ph.D., LABORATORY QUALITY ASSURANCE OFFICER:

Ph.D. in Chemistry, over 16 years experience in laboratory analysis. Analytical work performed through March, 1984.

THEODORE F. THEM, Ph.D., PROJECT CHEMIST:

Ph.D. in Analytical Chemistry, over 10 years experience in laboratory analysis. Analytical work performed through March 1984.

EARL HANSEN, Ph.D., LABORATORY MANAGER:

Ph.D. in Chemistry, 13 years experience in environmental consulting and project management; over 5 years of laboratory management and QA/QC experience related to inorganic and organic analyses of soil, water, air and waste sludges. Analytical work performed between March 1984 and January 1985.

CARTER KNOWLTON, Ph.D., MANAGER OF ORGANIC LABORATORY:

Ph.D. in Biochemistry, 14 years analytical experience in organic analyses using GC and GC/MS techniques; 7 years environmental chemistry consulting experience.

MR. GLENN SMART, PROJECT GEOLOGIST:

Regional geohydrologist for New England, B.S. in Hydrology with over 7 years experience in water resource and hazardous waste site investigations. Field work conducted since October 1984.

1.5.2 Subcontractors

All drilling and well construction for this project was performed by D. L. Maher Company of North Reading, Massachusetts.

Test pit excavation was performed by Mr. Richard Bunzick of South Dennis, Massachusetts, in December 1983, and by Robert Childs, Inc., also of South Dennis, in October 1984.

1.6 FACTORS OF CONCERN

Several factors of concern should be highlighted at the outset of this Problem Confirmation Study Report to be considered in the review of the information and findings presented herein.

- The Base overlies a thick sequence of permeable sands which constitute a high-yielding groundwater aquifer. This unconsolidated aquifer has been classified as a "sole source aquifer" under the provisions of the Safe Drinking Water Act, 1974, Section 1424e. Moreover, private and public groundwater supplies are located south and downgradient from Otis ANGB.

  In the fall of 1978, traces of methylene blue active substances (MBAS) were detected in Falmouth's Ashumet Well which have been linked to sewage discharges from Otis ANGB. Although no serious water quality health-related impacts have been identified with respect to consumption (WQTF, 1979), the water quality data indicate potential for off-site effects from previous Otis ANGB operations.

- The water table at Otis ANGB is generally more than 50 feet below land surface. Activities at land surface potentially can contaminate large volumes of unsaturated soils, thus creating increased complexity in the analysis of water quality problems and the identification of remedial actions.

  Furthermore, all streams on Otis ANGB are influent or losing streams. Influent streams discharge to the regional groundwater table rather than being recharged by the regional groundwater table. Prior spills to streams and storm drains ultimately can discharge to groundwater and impact groundwater quality.

- Groundwater constitutes a principal source of recharge to surface ponds downgradient from the Base. Hence, surface water bodies downgradient of Otis ANGB are particularly susceptible to contamination which might be present in groundwater exiting the Base.

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SECTION 2

ENVIRONMENTAL SETTING

2.1 REGIONAL GEOLOGY

Cape Cod, a large peninsula of glacial origin, extending into the Atlantic Ocean on the southeast corner of Massachusetts, is underlain by crystalline bedrock of Pre-Mesozoic age. A thick sequence of unconsolidated glacial sands and gravels, ranging in depth from 150 to 500 feet (Strahler, 1972), covers the region. The Cape was formed during the Pleistocene Epoch in the final ice stage (Wisconsin Stage) which began less than 70,000 years ago. As illustrated in Figure 2-1, Otis ANGB is situated near the contact zone of the Buzzards Bay Terminal Moraine and the Mashpee Outwash Plain.

During the latter part of the Wisconsin Stage of the Pleistocene Epoch (approximately 10,000 to 15,000 years ago) a vast continental glacier covered the New England Region. The ice sheet advanced southward, carrying with it a mixture of clay, sand, pebbles, and boulders which was smeared over the bedrock as dense deposits of "basal till." Other rock fragments were entrained within the ice mass and on its surface, and were deposited on top of the basal till as "ablation till" when the ice melted. In the Cape Cod area the melting process matched the rate of advancing ice, and ablation till was deposited along the ice margin. The ice sheet acted as a giant conveyor carrying more and more till to the toe of the glacier, eventually forming the Buzzards Bay and Sandwich Terminal Moraines.

The melting ice caused torrents of water to flow southward and eastward carrying with them rock fragments varying in size from boulders to clay particles. This "outwash" material was deposited as a broad plain sloping southward toward Nantucket Sound. As the velocity of the meltwater abated the largest particles were deposited first; as a result, the material underlying most of Otis ANGB is composed primarily of medium to coarse sands with cobbles

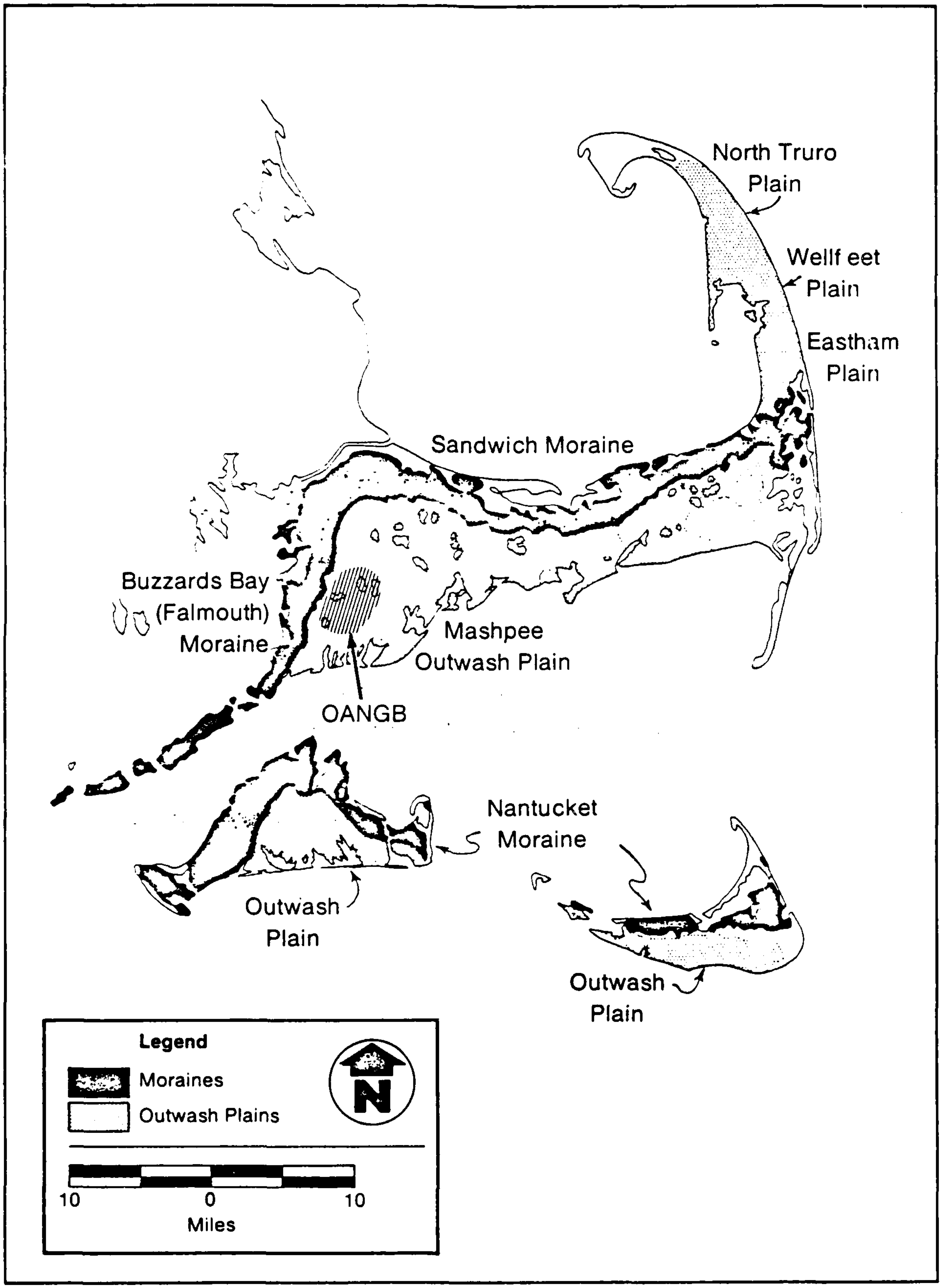

FIGURE 2-1 REGIONAL DISTRIBUTION OF GLACIAL DEPOSITS - CAPE COD

and gravel lenses extending to bedrock. The western extremity of the Base lies within the hummocky terrain characteristic of the Buzzard's Bay Terminal Moraine.

The saturated thickness of the outwash sands in the vicinity of Otis ANGB has been measured to be greater than 250 feet in some places. A test boring performed by American Drilling and Boring Company in 1973 was drilled to 258 feet without encountering bedrock (see Appendix D). Beyond 200 feet, the silt content increases and the deposits become finer with depth. A deep well in the Town of Harwick revealed the basement rock to be a phyllitic schist.

2.2 REGIONAL SOILS

Strahler (1966) found most of the soils on Cape Cod to be sandy loams of the "podzolic" type, which characteristically develop in rather wet climates in sandy areas. Rapid downward percolation of precipitation leaches nutrients from the upper soil layers rendering them poorly suited for the propagation of many plants and trees. Those trees that do grow, including certain species of pines, junipers, and oaks, are stunted. As the pine needles fall from the trees and decompose, they produce a weak acid solution which further aids the leaching process.

Selected soil samples, described by Vaccaro and others (1979) as part of a study for spray irrigation of treated sewage effluent on lands adjacent to the CFTA, indicated a layer of loam underlain by eolian (wind blown) sands. They report "clumps" of silty clay exhibiting distinct texture and color changes immediately below the surface (Vaccaro and others, 1979). Below 6 feet the fine eolian sands grade to medium sands, and deeper cores were reported to contain coarser sands with interspersed cobbles.

Vaccaro (1979) also observed and concluded that agricultural soils in the Otis ANGB area that were irrigated with sewage effluent consistently accumulated phosphorus, iron, manganese, copper, cadmium, chromium, nickel, and lead in the upper foot of top soil.

This information, provided by background sources, serves as background to the soil and analytical results obtained from this Phase II, Stage 1 Problem Confirmation investigation.

2.3 TOPOGRAPHY AND SURFACE DRAINAGE

Topography over most of the Base consists of a broad, flat, plain sloping gently to the south. Elevations generally range from 100 to 140 feet above mean sea level (MSL). Numerous depressions, frequently containing bogs or ponds, dot this area of Cape Cod. These depressions or "kettle holes" were formed when stagnant ice blocks were covered by outwash material and, as the ice melted, overlying material slumped, forming depressions. West and north of Otis ANGB, the topography becomes more irregular as the outwash plain meets the Buzzards Bay Terminal Moraine. Near the contact, elevations generally vary from 100 to 200 feet above MSL within Base boundaries. Surface slopes are typically less than 3 percent, except on the western portion of Otis ANGB or where man-made cut and fill structures exist.

Due to the highly permeable nature of the local sands and gravels allowing for rapid infiltration of precipitation. there are no perennial streams on Otis ANGB. Local streams are intermittent, meaning that they lose water to the surrounding soil and ultimately to the groundwater flow system. Natural drainage from the Base is primarily through the groundwater flow system. Some overland flow in swales at Otis ANGB ultimately discharges to ponds, which, in turn, flow to off-site streams and to the ocean. Historically, as Base housing, parking lots, and runways were constructed, runoff was directed into storm drains. According to the Phase I report (M&E, 1983) storm drains from the housing areas discharge to local ponds and depressions, while those draining the runway areas flow into three open drainage channels that direct the flow off-Base. Two of the drainage channels contain oil-water separators which discharge to Ashumet Pond and Johns Pond. Ashumet Pond does not overflow; Johns Pond discharges to the Childs River and the Quathnet River. The drainage systems, as identified from the Records Search (M&E, 1983), are illustrated on Figure 2-2.

2.4 CLIMATE

Cape Cod exhibits a humid continental climate that is modified by its close proximity to the Atlantic Ocean. This type of climate is characterized by moderate to large annual variations in temperature and sharp contrasts between seasons. Reported minimum mean daily temperatures at Otis ANGB ranged from a low of 23°F in February to a high of 63°F in July. Mean daily maximum temperatures range from 38° in January and February to 78° in July (Phase I Report). Precipitation averages 47.8 inches per year and is

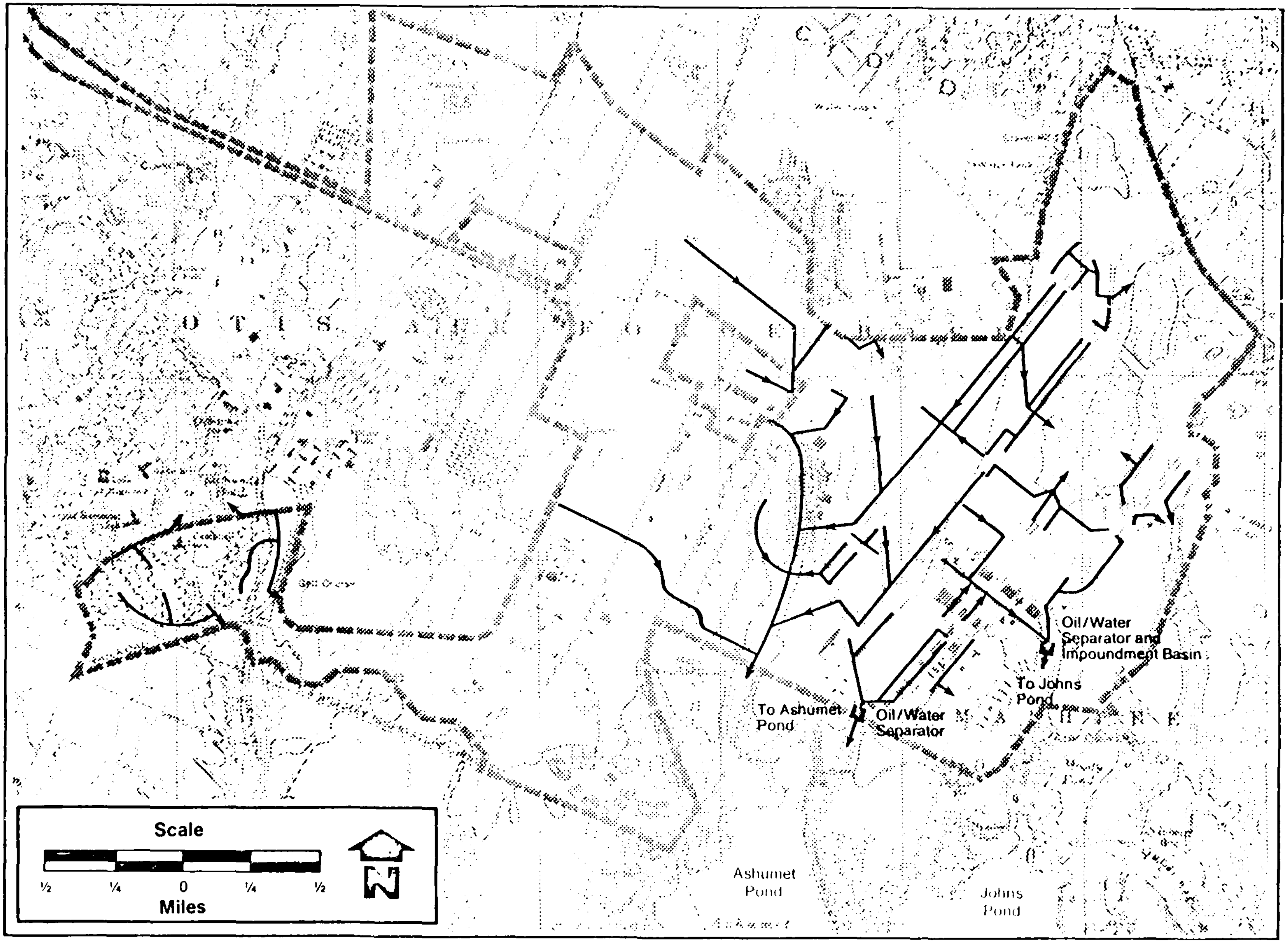

FIGURE 2-2 SURFACE DRAINAGE SYSTEMS AT OTIS AIR NATIONAL GUARD BASE

fairly evenly distributed throughout the year, with a mean monthly low of 2.0 inches in June and a mean monthly high of 4.8 in both January and August (M&E 1983). U.S. Weather Bureau records for Hyannis from 1931 to 1952 indicate an average precipitation rate of 42.8 inches (U.S. Department of Commerce, 1931 to 1952).

2.5 REGIONAL HYDROGEOLOGY

Otis ANGB is situated over a "sole source" aquifer of coarse-grained glacial outwash which acts as a single, homogeneous aquifer. Groundwater occurs under water table conditions in the outwash deposits. The approximated depth to the water table over most of the site is 50 feet. Estimates of regional hydraulic conductivities for this aquifer vary greatly. Vaccaro and others (1979) noted the existence of anisotropic conditions, with rates of 43 to 51 m/day (140 to 167 ft/day) in the north-south direction and 5.3 to 6.4 m/day (18 to 21 ft/day) in the east-west direction. Anisotropy refers to variances in the hydraulic conductivities within the aquifer system. It is further defined in Appendix A. The extent of aquifer anisotropy is conjectural at this point based on available data. LeBlanc (1982) found hydraulic conductivities of 61 to 91 m/day (200-300 ft/day) in the vicinity of the Base wastewater treatment facility.

The absence of perennial surface drainage systems on most of Cape Cod has resulted in the reliance on groundwater for most municipal water supplies. The shallow sand and gravel aquifer below Otis ANGB is particularly susceptible to contamination from surface contamination. A 1980 report compiled by Donovan R. Bowley of the Massachusetts Department of Environmental Quality Engineering (DEQE) notes that a leachate plume from the Otis ANGB sewage treatment plant has migrated 9,000 feet downgradient.

2.5.1 Base Groundwater Supply

As a result of a groundwater exploration program, five gravel packed production wells were constructed in 1940. These were designated Wells A, B, E, G, and J and are illustrated in Figure 2-3. Well A located adjacent to Well B, and Well E, located in the same depression as Well J, have been abandoned. Three wells, Wells B, G, and J, are still used, although Well B is used only for irrigation purposes.

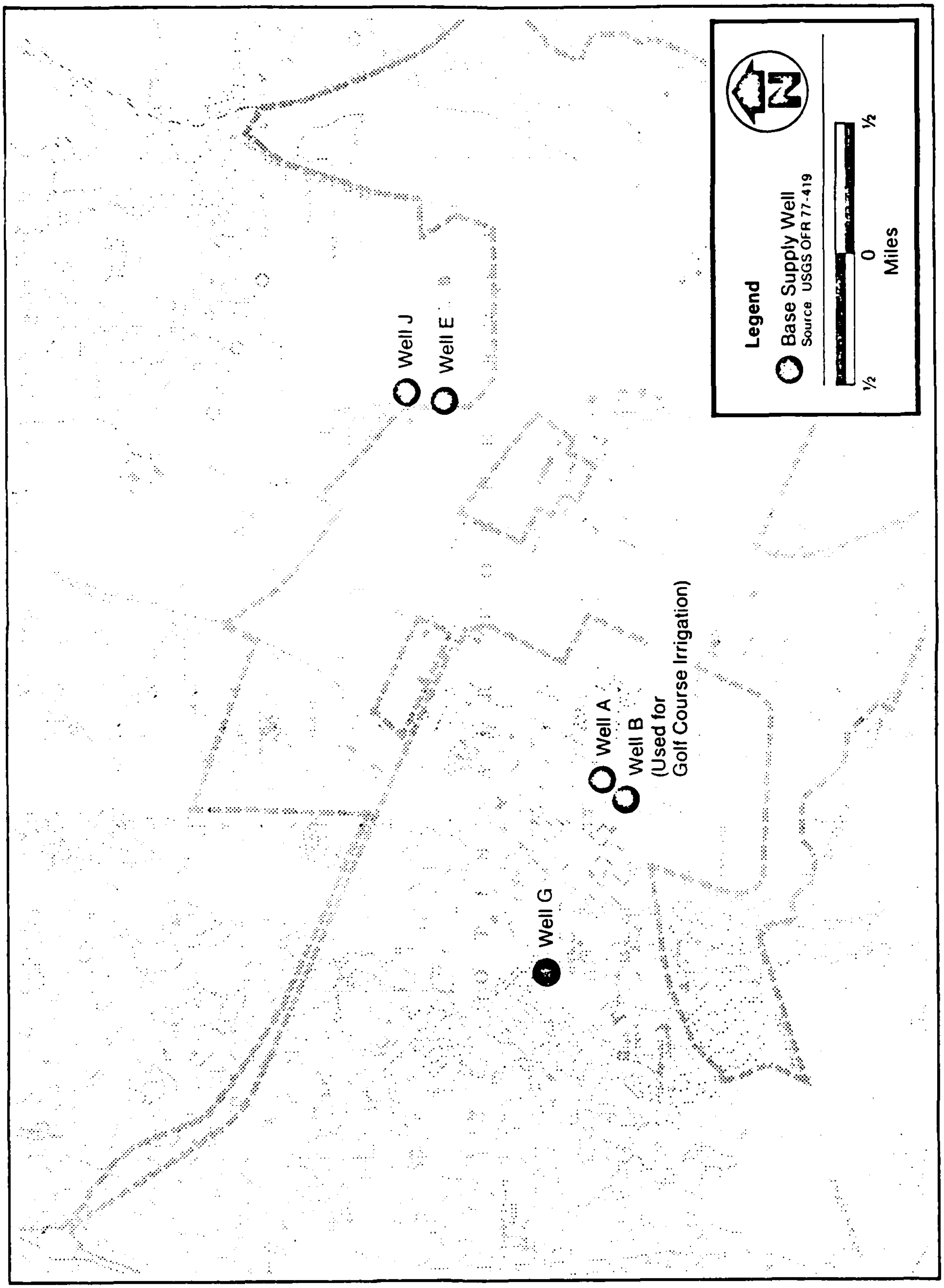

FIGURE 2-3 LOCATIONS OF WATER WELLS AT OTIS AIR NATIONAL GUARD BASE

Water quality data for Wells G and J were presented in the Phase I report (M&E, 1983). Well G exhibits low levels of contamination with volatile organic compounds based on analyses performed between 1979 and 1982. There have been no indications in Well J of contamination with organic compounds.

A regional groundwater flow map provided by M&E (1983), based on USGS data from a limited number of points, is illustrated in Figure 2-4. Based on this map flow in the regional aquifer in the vicinity of Otis ANGB generally is to the south.

The foregoing summarizes the information available on site conditions, which constituted the basis for the design of the Phase II, Stage 1 Problem Confirmation Study.

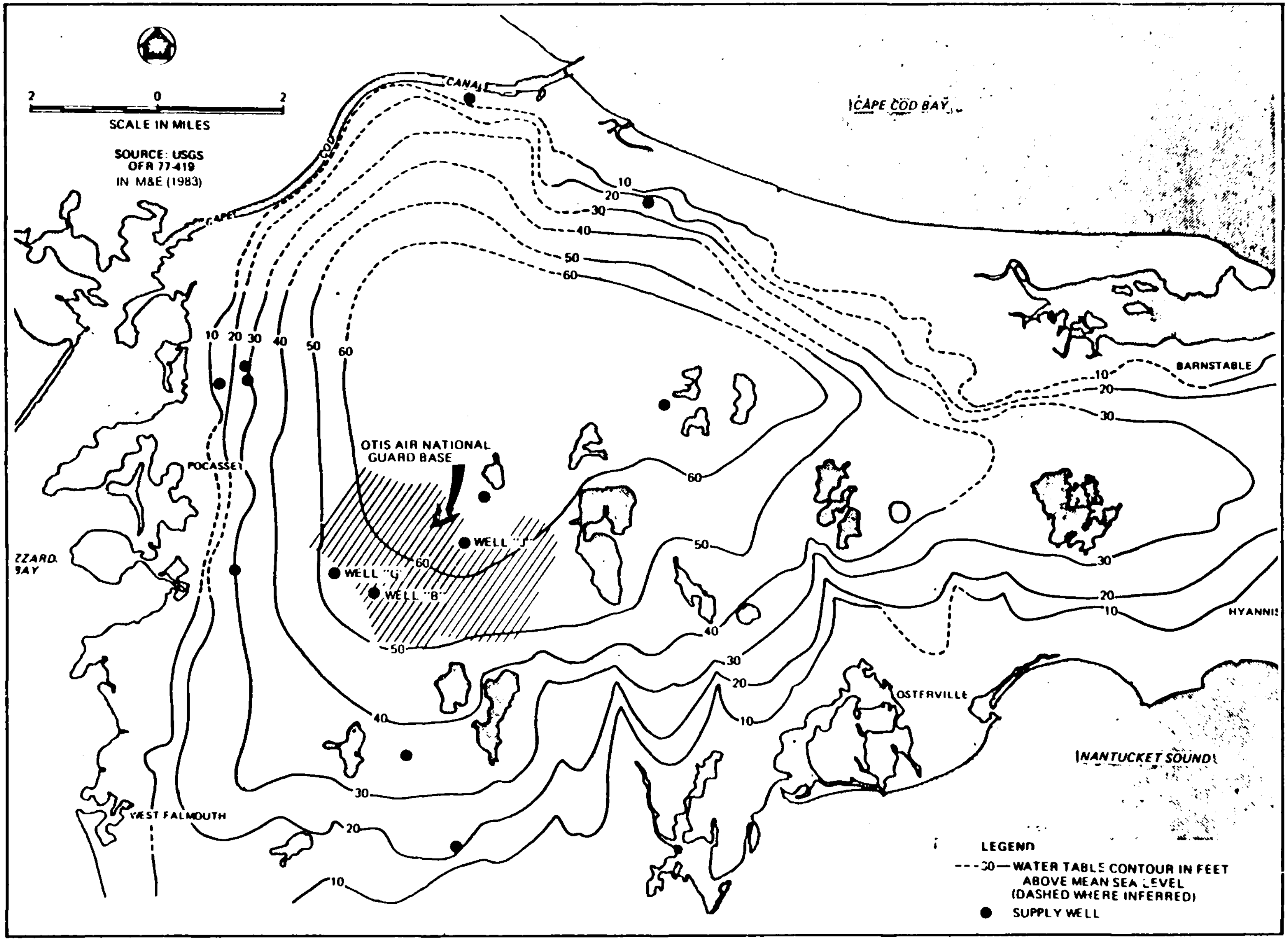

FIGURE 2-4 REGIONAL WATERTABLE MAP

SECTION 3

FIELD PROGRAM

3.1 PROGRAM DEVELOPMENT

Based on the conclusions of the Phase I Records Search, the Phase II Presurvey Report, and the overall relative HARM score ratings, six of the ranked sites and the Petrol Fuel Storage Area were recommended for Confirmation Stage Investigations. Two sites were grouped together for efficiency of field investigation so that a total of six areas were investigated. The six areas are designated as:

- Current Fire Training Area (CFTA)
- Former Fire Training Area and Non-Destructive Inspection Laboratory (FFTA/NDI)
- Base Landfill
- Avgas Fuel Test Dump Site (AFTDS)
- Railyard Fuel Pumping Station (RFPS)
- Petrol Fuel Storage Area (PFSA)

Task Order 0028 is included in Appendix B for reference. This task order was the basis for the implementation of the field program described subsequently. All of the task order modifications which were initiated in October 1984 are underlined in Appendix B.

3.1.1 Current Fire Training Area (CFTA)

At the CFTA a backhoe test pit investigation was recommended. It was also proposed that soils from the test pits be field screened with a photo-ionization detector (HNu) to determine if detectable levels of volatile organic contaminants were present. Based on the field data, a maximum of 10 soil samples were to be collected from the test pits for laboratory analysis.

Three monitor wells (one upgradient and two downgradient) were proposed at the CFTA to sample groundwater and to measure water table elevations. In consultation with OEHL, the proposed upgradient well was subsequently deleted from the scope of work.

3.1.2 Former Fire Training Area/Nondestructive Inspection Laboratory (FFTA/NDI)

A backhoe test pit investigation was proposed to better identify the size of the FFTA/NDI and to obtain up to six subsurface soil samples for laboratory analysis. All soil samples would be field screened for volatile organic contamination using an HNu.

A single downgradient monitoring well was recommended to monitor this zone. Its proposed downgradient location, adjacent to a drainage swale, was selected as the optimal site to intercept a contaminant plume if it were emanating from the site.

In addition to the work recommended at the FFTA/NDI site in the Phase I report, the Presurvey Report proposed collection of one liquid and one sludge sample from the sump tank at the NDI.

3.1.3 Base Landfill

The WESTON Phase II Presurvey Report recommended that a backhoe test pit investigation be performed to approximately delineate the lateral extent of the landfilling operation. Analysis of archival aerial imagery revealed extensive land surface disturbance possibly related to gravel extraction operations prior to landfilling, thus making it difficult to determine the optimum well locations to monitor the site.

The drilling program at the landfill was reduced from the five wells proposed in the Presurvey Report to a four-well array by eliminating the upgradient monitor well. Due to the homogeneous nature of the aquifer and the absence of any confining beds, multi-level monitor wells were unnecessary for the Confirmation Study.

3.1.4 Avgas Fuel Test Dump Site (AFTDS)

The proposed contract modification work at the AFTDS was directed toward determining areas affected by fuel dump operations. To accomplish this, a backhoe test pit investigation of the suspect area was proposed. Screening of soils for volatile organics using an HNu meter was recommended. Up to four soil samples were proposed for laboratory analysis. A single remote downgradient monitor well was proposed to detect possible environmental impacts from prior use at this area. The proposed well was to be constructed in the uppermost portion of the water table aquifer to detect the possible presence of hydrocarbon contamination by Avgas product.

3.1.5 Railyard Fuel Pumping Station (RFPS)

As part of the supplemental site work developed in the contract modification, a backhoe test pit investigation was proposed in the vicinity of the loading racks and transmission lines to establish the presence of near surface soil contamination with petroleum products. Soils would be field screened for the presence of volatile organics, using an HNu. Up to four samples were scheduled for laboratory analysis.

Two downgradient wells were proposed to monitor for hydrocarbons such as JP-4 and Avgas in the uppermost zones of saturation. Sampling of a header pipe at the loading rack and a transmission pipe at the former pumping station was also proposed because solvent-like odors had been noted at these locations.

3.1.6 Petrol Fuel Storage Area (PFSA)

The proposed modification work at the unranked PFSA in the modified task order entailed the construction of a monitor well downgradient of the facility into the uppermost portion of the aquifer. The purpose of this well was to detect the possible presence of petroleum product from the existing PFSA which had been in operation since the early 1950's.

3.1.7 Analytical Protocol

An analytical protocol was selected for all sites to provide indicators of specific and nonspecific contamination. Table 3-1 lists the parameters analyzed for at each site in the initial investigation and Table 3-1-1 gives the analytical protocol for the supplemental analyses proposed in the task

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TABLE 3-1

Analytical Protocol for Original Phase II Sites

Site	Sample Type and Number	Analytes[1]
CFTA	2 groundwater	TOC, TOX, O&G, PCB, Pb,
	10 soil	TOX, O&G, Pb
FFTA/NDI	1 groundwater	TOC, TOX, O&G, Pb,
	6 soil	TOX, O&G, Pb
	1 liquid (NDI sump tank)	TOC, TOX, O&G, Pb
	1 sludge (NDI sump tank)	TOX, O&G, Pb
Base Landfill	4 groundwater	TOC, TOX, O&G, CN, Phenol, PCB, Fe, Cu, Cd, Cr, Pb, As, Ni, Endrin, Lindane, Methoxychlor, Toxaphene, 2,4-D, 2,4,5-TP (Silvex)

[1] See definitions of abbreviations in Table 3-2

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TABLE 3-1-1

Supplementary Analytical Protocol for Phase II Sites

Site	Sample Type and Number	Analytes[1]
CFTA	2 groundwater	TOC, phenols, VOA incl. xylene, MEK, MIBK, IR-scan
FFTA/NDI	1 groundwater	TOC, phenols, VOA incl. xylene, MEK, MIBK, IR-scan
Base Landfill	4 groundwater	TOC, Phenols, VOA incl. xylene, MEK, MIBK, IR-scan, hardness, sulfate, chloride, nitrate-N, ammonia-N, TKN, dissolved Fe
AFTDS	1 groundwater	Phenols, VOA, Pb, GC-scan (hydrocarbons)
	4 soils	Phenols, VOA, Pb, GC-scan (hydrocarbons)
RFPS	2 groundwater	Phenols, VOA, Pb, O&G, GC-scan (hydrocarbons)
	4 soils	Phenols, VOA, Pb, GC-scan (hydrocarbons)
	2 waste oil	Pb, GC-scan (hydrocarbons), acid- and base-neutral extractables.
PFSA	1 groundwater	Phenols, Pb, GC-scan (hydrocarbon), VOA

[1] See definitions of abbreviations in Table 3-2

order modification. Table 3-2 gives the required detection limits for the analytes of concern.

3.2 FIELD INVESTIGATION

An initial field investigation was conducted in late 1983 and early 1984 to define the hydrogeologic and geologic setting, and to detect the possible presence of hazardous environmental contaminants that may have resulted from past disposal and operational practices at the CFTA, the FFTA/NDI and the Base Landfill at Otis ANGB. In the fall of 1983, a total of 33 backhoe test pits were excavated and 7 monitor wells were installed to obtain data on local groundwater gradients and flow directions, and to provide environmental sampling points to assess local groundwater quality in the vicinity of the three investigated sites. In early 1984, two replacement wells had to be installed at the Base Landfill after difficulties were encountered sampling with the 2-inch submersible pump. Two of the original wells, RFW-2 and RFW-3, had bent casings.

As a result of a task order modification (Appendix B), a total of 30 additional test pits and 4 additional monitor wells were installed in October 1984. A second round of sampling was approved for the original seven wells, RFW-1 through RFW-7, and an initial round of sampling was authorized for supplemental wells RFW-8 through RFW-11. This additional field work not only provided original Confirmation Stage Information for three additional sites (AFTDS, RFPS, and PFSA), but also expanded on the data base available for the original sites and for interpretation of the overall hydrogeologic setting of Otis ANGB.

3.2.1 Test Pit/Drilling Program

Prior to the installation of monitor wells at the sites of concern, the test pit excavation program was initiated to obtain shallow soil samples for laboratory analysis and to determine the lateral extent of the sites. Mr. Richard Bunzick of South Dennis, Massachusetts was contracted to excavate the original 33 test pits. The work was accomplished between 30 November and 1 December 1983. Robert Childs, Inc. of South Dennis, Massachusetts was contracted to perform the backhoe work for the AFTDS and RFPS. This work was completed in October 1984. Test pit logs are contained in Appendix D. Table 3-3 summarizes the test pit and soil sampling work at the three sites completed in 1983.

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TABLE 3-2

Analytical Methods and Required Detection Limits

Analytes	Level of Detection Required		Contract Method
Total Organic Carbon (TOC)	1	mg/L	EPA 415.1
Total Organic Halogens (TOX)	5	ug/L (w); 5 ug/g (s)	EPA 9020
Oil and Grease by Infrared Method (O&G)	0.1	mg/L (w); 100 ug/g (s)	EPA 413.2
Cyanide (Cn)	10	ug/L	EPA 335.2
Phenols	1	ug/L (w); 1 ug/g (s)	EPA 420.1
Polychlorinated Biphenyls (PCB)	0.25	ug/L	EPA 608
Iron (total dissolved) (Fe)	100	ug/L	EPA 200.7
Copper (Cu)	50	ug/L	EPA 200.7
Cadmium	10	ug/L	EPA 213.2
Chromium (Cr)	50	ug/L	EPA 200.7
Lead (Pb)	20	ug/L (w); 2 ug/g (s)	EPA 239.2
Arsenic (As)	10	ug/L	EPA 206.2
Nickel (Ni)	100	ug/L	EPA 200.7
Endrin	0.02	ug/L	SM 509A
Lindane	0.01	ug/L	SM 509A
Methoxychlor	0.2	ug/L	SM 509A
Toxaphene	1.0	ug/L	SM 509A
2,4-D	0.06	ug/L	SM 509B
2,4,5-TP Silvex	0.02	ug/L	SM 509B
Xylene	1	ug/L	EPA 624
Methyl isobutyl ketone (MIBK)	1	ug/L	EPA 624
Methyl ethyl ketone (MEK)	1	ug/L	EPA 624
Sulfate	1	ug/L	EPA 300.0
Chloride	1	ug/L	EPA 300.0
Hardness	--		EPA 130.2
Infrared Scan (IR scan)	--		EPA 418.1
Ammonia as Nitrogen	--		EPA 350.3
Hydrocarbon GC Scan	--		see description in App. C
Total Kjeldahl Nitrogen	--		EPA 351.4
Nitrate as Nitrogen	--		EPA 300.0
Volatile Organic Compounds (VOA)	(1)		EPA 601/602
Base/Neutrals and Acids	(2)		EPA 625

(w) = water

(s) = soil

(1) = Detection levels for volatile aromatics and volatile halocarbons shall be as specified in EPA Methods

(2) = Detection levels for base neutrals and acids shall be as specified in EPA Method 625.

TABLE 3-3

SUMMARY OF 1983 TEST PIT AND SOIL SAMPLING DATA

Site and Test Pit No.	Total Depth (ft)	Number of Samples	Approximate Interval (ft)	Comments
Base Landfill				
1	10.0	0	-	Burnfill ~10' thick
2	10.0	0	-	Burnfill ~5' thick
3	6.5	0	-	No fill - natural
4	8.5	0	-	Unburned refuse 4' thick
5	7.0	0	-	Unburned refuse 3' thick
6	7.0	0	-	Refuse, unknown depth- 5' cover
7	6.5	0	-	No fill - natural
8	4.5	0	-	No fill - natural
9	6.0	0	-	No fill - natural
Current Fire Training Area				
10	8.5	3	1,3,7	Oil stained area,hydrocarbon odor
11	9.0	3	2,4,9	Oil stained area - HNu 20 ppm @ 2'
12	10.0	2	4,9	HNu 20 @ 4', HNu 10 ppm @ 10'
13	6.0	1	4	HNu 15 ppm @ 2', HNu 0 ppm @ 5'
14	6.5	1	4	HNu 15 ppm @ 6.5'
15	8.5	1	3	No hydrocarbon odors, HNu = 0
16	6.0	2	2,6	Slight hydrocarbon odor
17	4.0	1	3	No oil odor; HNu 5 ppm @ 4'
18	8.0	0	-	HNu - 0 througout profile
Non-Destructive Inspection Lab				
19	6.9	1	6	Granular clean fill
20	4.0	0	-	Granular clean fill
21	1.5	1	1	HNu 0 @ 1.5'
22	1.5	1	1	HNu 0 @ 1.5'
Former Fire Training Area				
23	1.0	0	-	Thick macadam - Impenetrable
24	2.5	0	-	Macadam Fill - HNu-0
25	9.0	1	9	HNu background
26	3.5	0	-	Burnfill - HNu-0
27	5.0	0	-	Cinders & burn fill - HNu-0
28	12.0	1	11	Burnfill - HNu-0-1
29	5.0	0	-	HNu-0 (background)
30	4.5	0	-	HNu-0 (background)
31	5.0	0	-	Burnfill - HNU-0
32	6.0	0	-	Clean Fill - HNu-0
33	5.5	1	6	Burnfill - HNu-0

Note: Soil samples from which certain samples selected for analysis.

Table 3-3-1 summarizes the supplementary test pit work completed in October 1984.

A total of 13 monitor wells (including two replacement wells) were installed at Otis ANGB by the D. L. Maher Company of North Reading, Massachusetts between 6 December 1983 and 18 October 1984. Exploratory borings were performed with a Gus Pech hollow-stem auger rig. Soil samples were taken every 10 feet by driving a standard 2-inch diameter, 2-foot long split-spoon sampler, using Standard Penetration Test (SPT) techniques (ASTM Standard Method No. D-1586). Replacement wells RFW-2A and 3A were constructed adjacent to RFW-2 and RFW-3 and, therefore, were not sampled by split-spoon. All soil samples were retained in archives at the WESTON office in Concord, New Hampshire. An HNu photo-ionization detector was used to screen split-spoon samples and air quality at the well head for the presence of detectable organic vapors. Each boring was advanced to depths of approximately 20 to 50 feet below the water table depending on the recommended monitoring protocols.

Permanent monitor wells were installed in borings RFW-1 through RFW-7 using 2-inch nominal diameter Schedule 80 polyvinyl chloride (PVC) pipe, with threaded couplings and fifty feet of Schedule 80 PVC No. 10 (0.010 inch) machine slotted well screen. In wells RFW-8 through RFW-11, 20 feet of screen extending 3 feet above the water table was installed to monitor floating hydrocarbons at these sites.

After the PVC pipe was placed into the boring, the augers were removed to a point approximately 10 feet above the top of the screen. The formation sands were allowed to collapse around the screen to act as a natural gravel pack. A bentonite grout was subsequently pumped through a tremie line to form an impermeable seal above the sand. A thinner bentonite slurry was then tremied into the annular space as the augers were removed allowing the collapsing formation sands to mix with the bentonite. Finally, a protective black steel casing with a locking cap was installed over the PVC casing in a 2-foot concrete seal.

The finished wells were developed by lowering a 1/2-inch steel pipe to approximately one foot above the bottom of the PVC screen and blowing air down the pipe to force the water and fine-grained formation material out of the well. In wells with deep static water levels, the steel pipe was lowered inside a 1 1/4-inch black PVC sleeve acting as an

TABLE 3-3-1

Summary of 1984 Test Pit and Soil Sampling Data

Site and Test Pit No.	Total Depth	Samples	Approximate Interval (ft)	Comments
Railyard Fuel Pumping Station				
TP-1	10.5	1	1-2.5	Sand, gravel, railroad ballast
TP-2	8.5	No	-	Sand, gravel, railroad ballast
TP-3	8.5	No	-	Sand, gravel, railroad ballast
TP-4	8.0	No	-	Sand and gravel
TP-5	8.0	No	-	Hardpan at approximately 2.0
TP-6	10.0	No	-	Hardpan from 18-24", silt layer at 3'
TP-7	10.0	No	-	Hardpan at 18", discontinuous oxided layer
TP-8	10.0	No	-	Highly oxided sand and gravel
TP-9	8.0	1	4-8	Layer of silt and pebbles from 1' to 4'
TP-10	10.0	No	-	Hardpan at 2.5
TP-11	10.0	No	-	Hardpan from 1-2'
TP-12	10.0	No	-	6"-6' silt layer dipping at 30°
TP-13	10.0	No	-	Oxidized sand and gravel
TP-14	9.0	1	1-3	Oxidized gravel, silt layer
TP-15	10.0	No	-	Oxidized gravel, silt layer
TP-16	10.0	1	0.5-1.0	Discolored layer at 1'
TP-17	9.0	No	-	Discolored layer at 8"
TP-18	9.0	No	-	Discolored soil from 0.5-2'
Avgas Fuel Test Dump Site				
TP1A	10.0	No	-	Sand and gravel
TP2A	10.0	No	-	Sand and gravel
TP3A	10.0	1	0.5-1	Discolored layer at 8"
TP4A	9.0	No	-	Sand and gravel
TP5A	8.0	No	-	Sand and gravel
TP6A	10.0	1	5	Discolored sand and debris from 2-6'
TP7A	8.0	1	1-3	Discolored layers of soil 1-3.5'
TP8A	10.0	1	2	Discolored layer at 2'
TP1B	9.0	No	-	Stratified sand and gravel, black layer at 5'
TP2B	9.0	No	-	Layer of peat at 7'
TP3B	9.0	No	-	Layer of peat at 7'
TP4B	8.0	No	-	Interbedded sand and gravel

eductor pipe for pumped water and sand. The purging process continued until the discharging water was as free of sand as practicably possible.

All drilling, well construction, and well development procedures were supervised by qualified WESTON personnel. Following the well completion, a locking cap and padlock were attached to the protective casing to maintain adequate security. Figures 3-1 and 3-1-1 contain well completion diagrams for each of the monitor wells constructed at Otis ANGB. The logs of the borings and well construction are included in Appendix D. Construction details of all wells are summarized in Table 3-4.

3.2.1.1 Current Fire Training Area (CFTA)

From 30 November to 1 December 1983, nine backhoe test pits, designated TP-10 through TP-18, were installed around the perimeter of the CFTA to delineate the probable lateral extent of surface spillage and vertical extent of near surface contamination. An HNu photo-ionization detector was used during the digging operations to monitor the presence of volatile organic vapors. The test pit locations are depicted on Figure 3-2.

Two monitor wells were installed downgradient of the CFTA. Construction details of these wells are summarized in Table 3-4 and the field logs are appended to this report. The locations of wells RFW-5 and RFW-6 are illustrated in Figure 3-2.

3.2.1.2 Former Fire Training Area/Nondestructive Inspection Laboratory (FFTA/NDI)

Fifteen backhoe test pits were dug on 1 December 1983; four (TP-19 through TP-22) were excavated at the NDI, and eleven were dug around the FFTA. The test pit locations are shown on Figure 3-3. The objective of the test pit investigation at the NDI facility was to collect soil samples to detect whether or not there had been seepage or discharges from the on-site disposal tank and leachfield into surrounding soils. Samples in the swale below the NDI laboratory were collected up- and downstream from the site. Test pits at the FFTA were dug to locate the site and to detect the potential impacts, if any, of site use. An HNu was used to screen soil samples. Two soil samples from the NDI and two soil samples from the FFTA were selected for analysis.

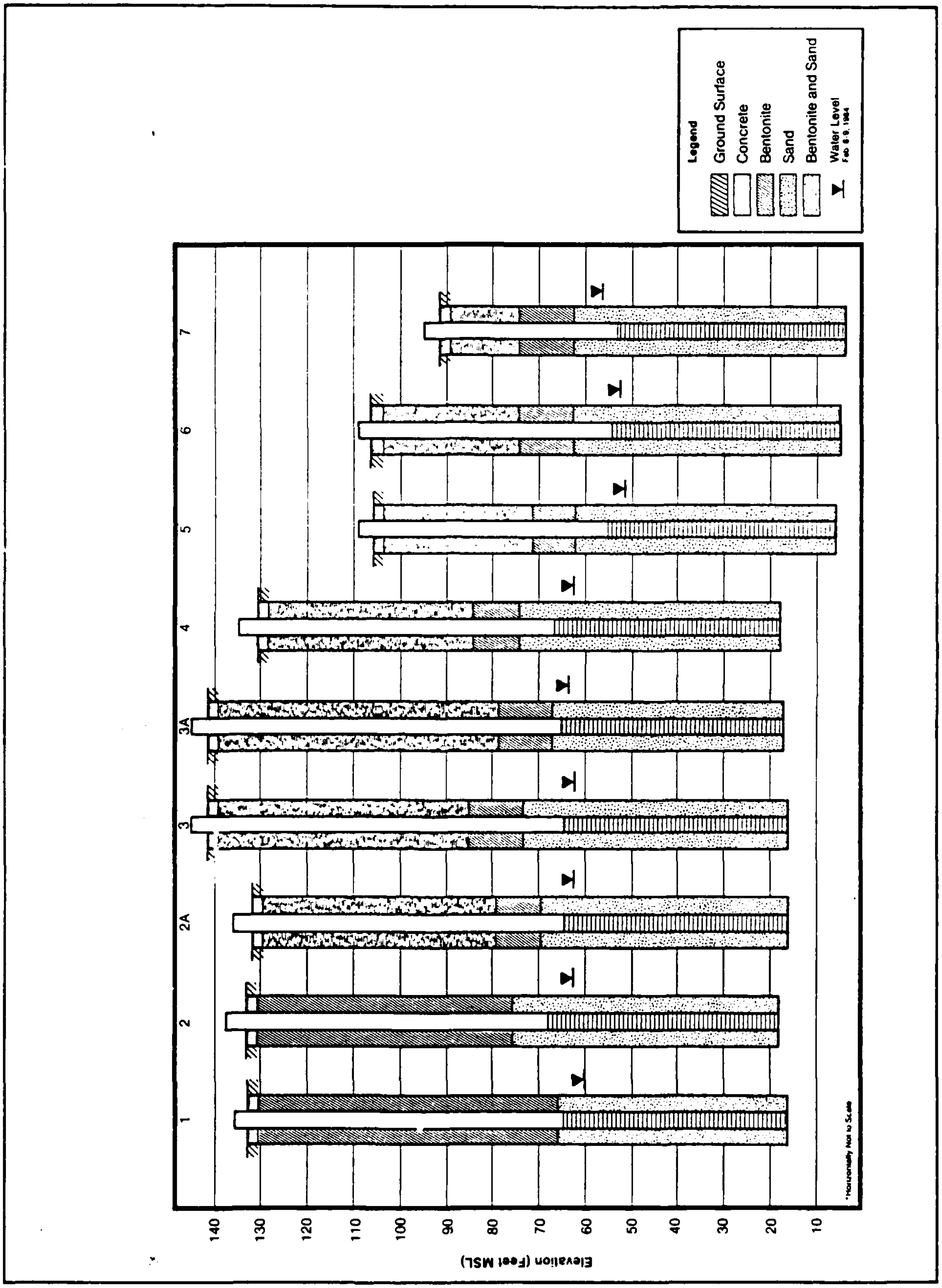

FIGURE 3-1 WELL COMPLETION DIAGRAM, RFW-1 THROUGH RFW-7

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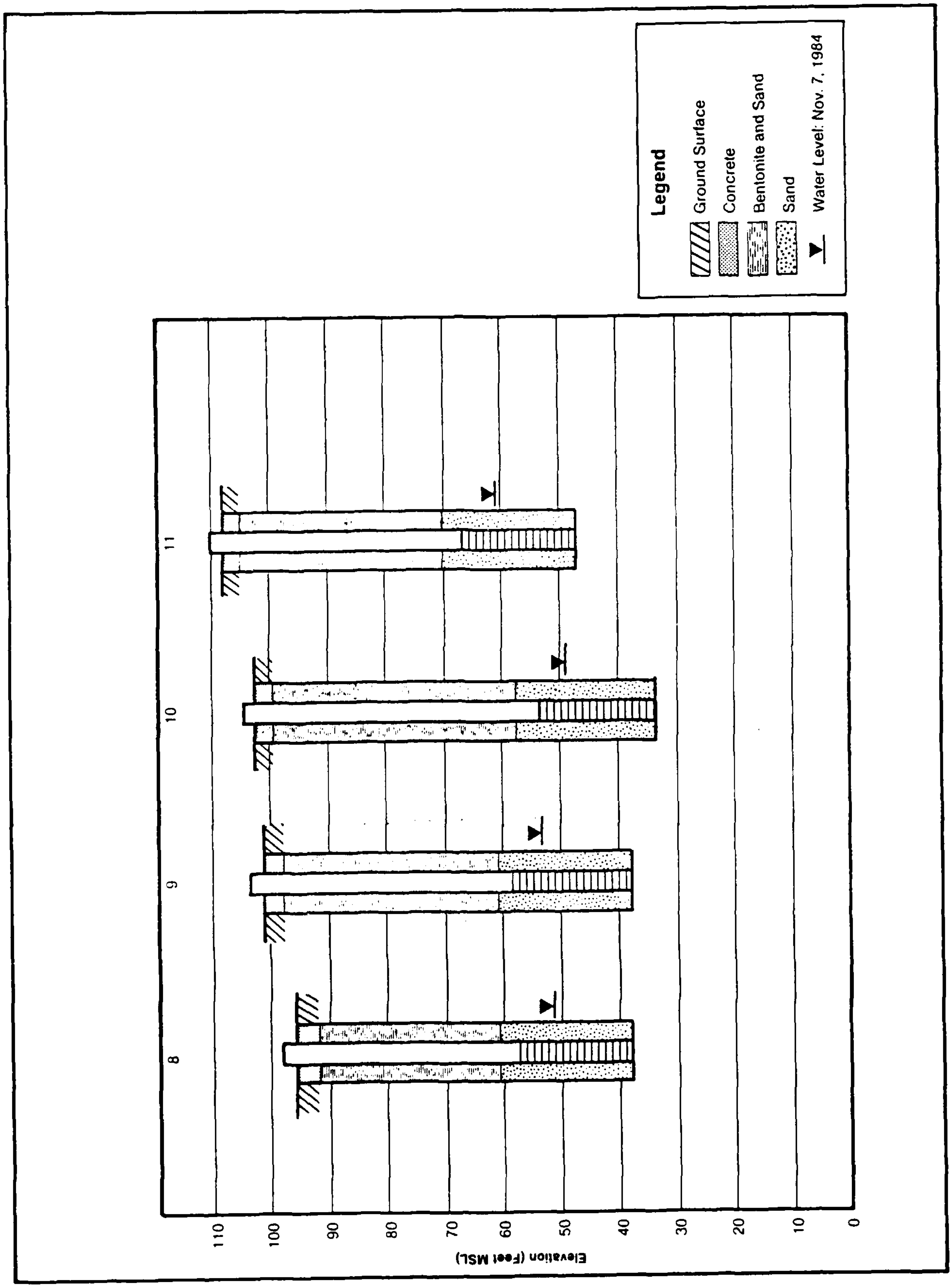

FIGURE 3-1-1 WELL COMPLETION DIAGRAM, RFW-8 THROUGH RFW-11

TABLE 3-4

Summary of Monitor Well Construction Details

Well No.	Approx. Land Surface Elev. (ft)	TOC[1] (ft)	Depth Below Ground Surface: Screened Interval (ft)	Depth Below Ground Surface: Natural Sandpack (ft)	Depth Below Ground Surface: Pure Bentonite Clay Seal (ft)	Geology of Screened Zone[2]
RFW-1	133.0	135.60	69 - 119	68 - 122	0 - 68	f to c sand, & gravel, trace silt
RFW-2	133.5	136.73	70 - 120	60 - 120	40 - 20	m to c sand, little f gravel
RFW-2A	132.9	135.79	70 - 120	65 - 120	55 - 65	similar
RFW-3	143.0	145.74	80 - 130	70 - 130	58 - 70	m to c sand, little f to m gravel
RFW-3A	143.0	146.16	80 - 130	77 - 130	65 - 77	similar
RFW-4	131.3	135.50	68 - 118	58 - 118	48 - 58	f to c sand, little gravel
RFW-5	107.4	109.91	55 - 105	45 - 105	36 - 45	similar
RFW-6	105.9	109.17	55 - 105	45 - 105	33 - 45	similar
RFW-7	90.9	93.31	30 - 90	30 - 90	17 - 30	similar
RFW-8	93.39	95.45	38 - 58	35 - 58	31 - 35	m to c sand, little m gravel
RFW-9	99.83	101.36	43 - 63	40 - 63	30 - 40	m to c sand, & gravel
RFW-10	100.82	102.97	49 - 69	46 - 69	40 - 45	f to c sand
RFW-11	106.47	108.69	41 - 61	36 - 61	26 - 36	m to c sand, & f to m gravel

(1) TOC = Top of Casing

(2) f = fine, m = medium, c = coarse

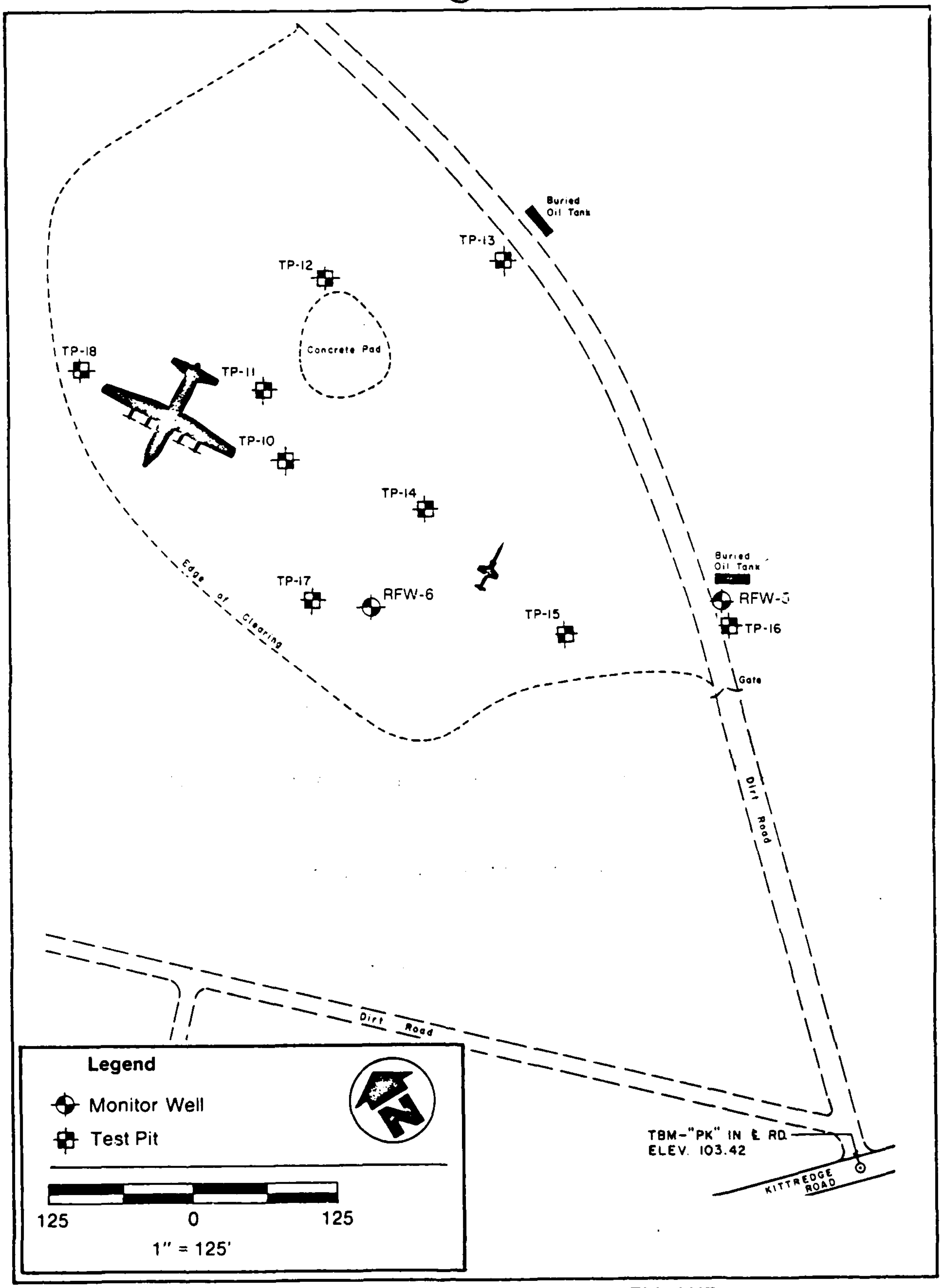

FIGURE 3-2 MAP OF CFTA SHOWING WELL AND TEST PIT LOCATIONS

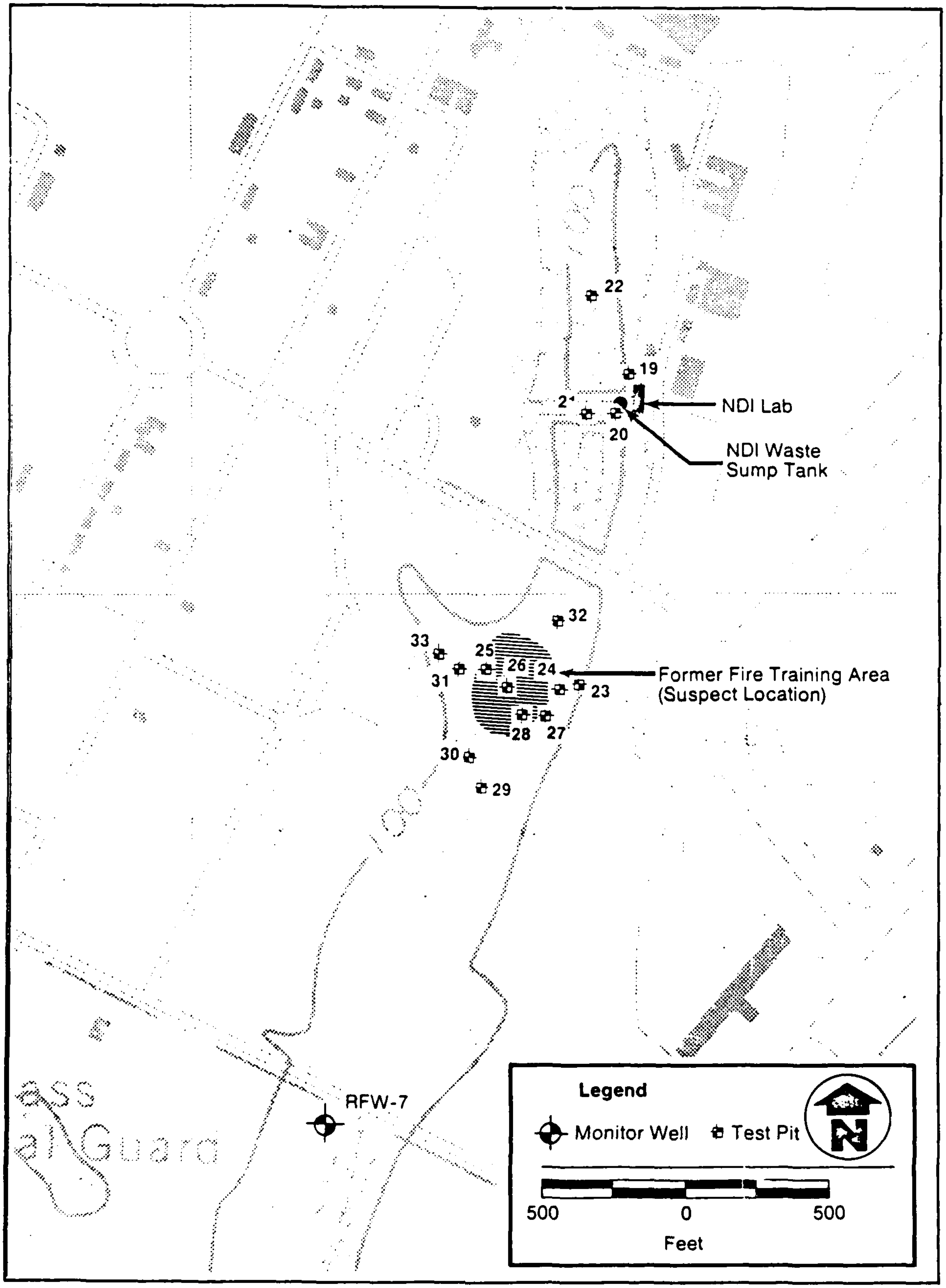

FIGURE 3-3 MAP OF FFTA/NDI SHOWING WELL AND TEST PIT LOCATIONS

Well RFW-7 was located hydraulically downgradient of the NDI/FFTA. The well location is shown on Figure 3-3. The positioning of the well was based on regional flow inferences (Figure 2-4), topography with respect to the runway and nearby drainage swale, and anticipated flow rates in the aquifer. The well is intended to monitor potential environmental effects from either the NDI or the FFTA.

3.2.1.3 Base Landfill

Nine backhoe test pits were installed in the area of the Base Landfill on 30 November 1983. The data gathered were used to delineate the extent of the landfilling operations and to determine optimal monitoring well locations. Figure 3-4 depicts the approximate test pit locations at the Base Landfill.

Four monitor wells were later installed along the downgradient perimeter of the landfill. Due to the homogeneity of the aquifer, it was decided to install single wells, screened over the upper 50 feet of the aquifer at each of the sites. The 50-foot screens should intercept landfill derived leachate migrating off-site and provide representative samples for the upper portion of the aquifer, for the purpose of problem confirmation. The well locations at the Base Landfill are also shown on Figure 3-4.

3.2.1.4 Avgas Fuel Test Dump Site (AFTDS)

Twelve test pits were dug to evaluate potential contamination of soil material as a result of past practices at the Avgas Fuel Test Dump Site. Eight pits were dug in the vicinity of the dump site (TP-1A through TP-8A). These are illustrated on Figure 3-5. Four additional remotely located test pits were excavated in the depression southwest of the site (TP-1B through TP-8B); the approximate locations of the remote test pits are shown on Figure 3-5-1. During the excavation of the test pits, HNu readings were taken of the soils to detect the presence of volatile organic compounds. Four soil samples, exhibiting what appeared to be staining, were collected for analysis.

Because the regional groundwater flow direction is to the south, a single well south of the suspect site was installed. Avgas was the chief component of concern; therefore, the well was planned to intersect the uppermost water bearing deposits and extend slightly above the water table

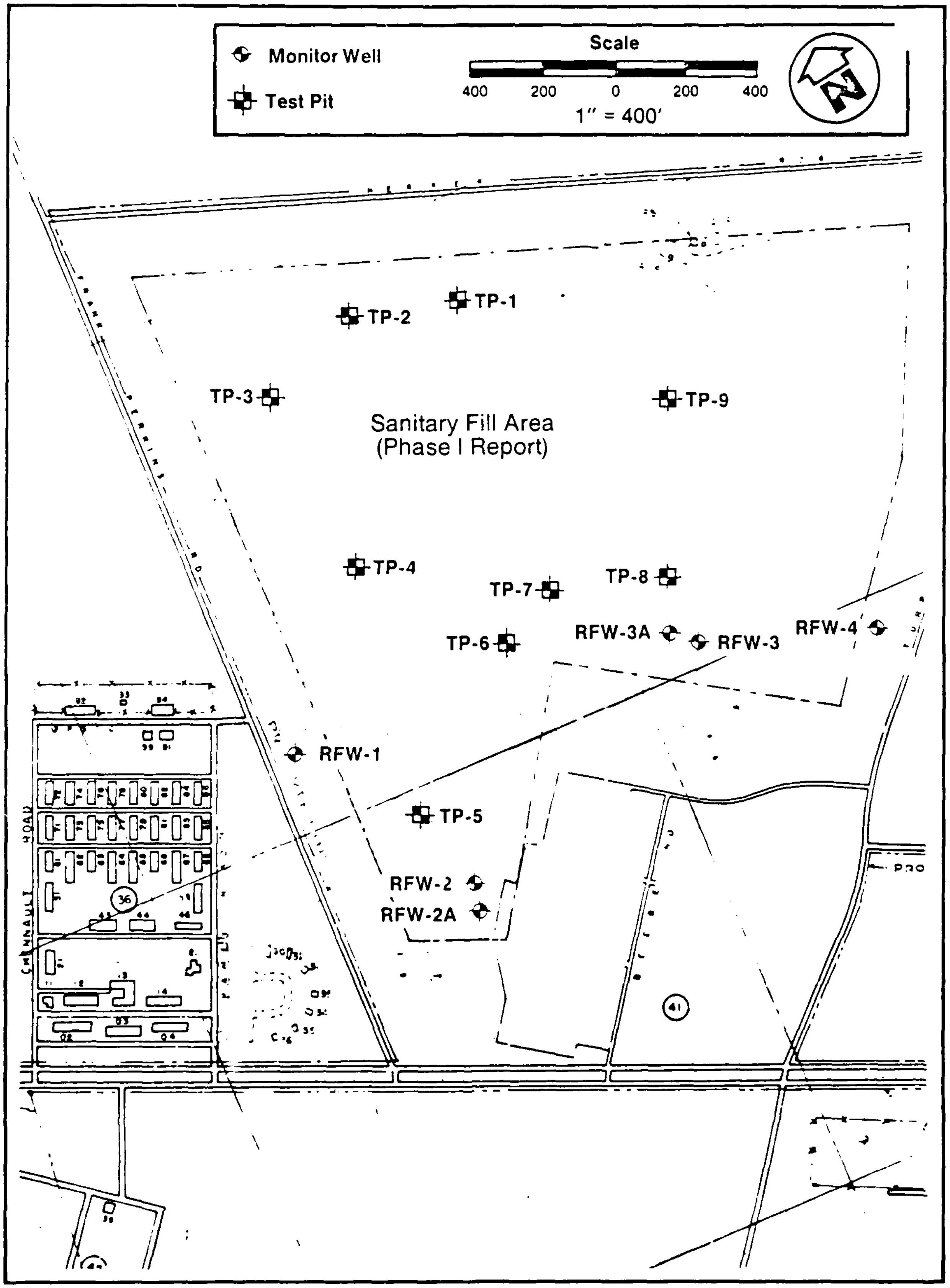

FIGURE 3-4 MAP OF BASE LANDFILL SHOWING WELL AND TEST PIT LOCATIONS

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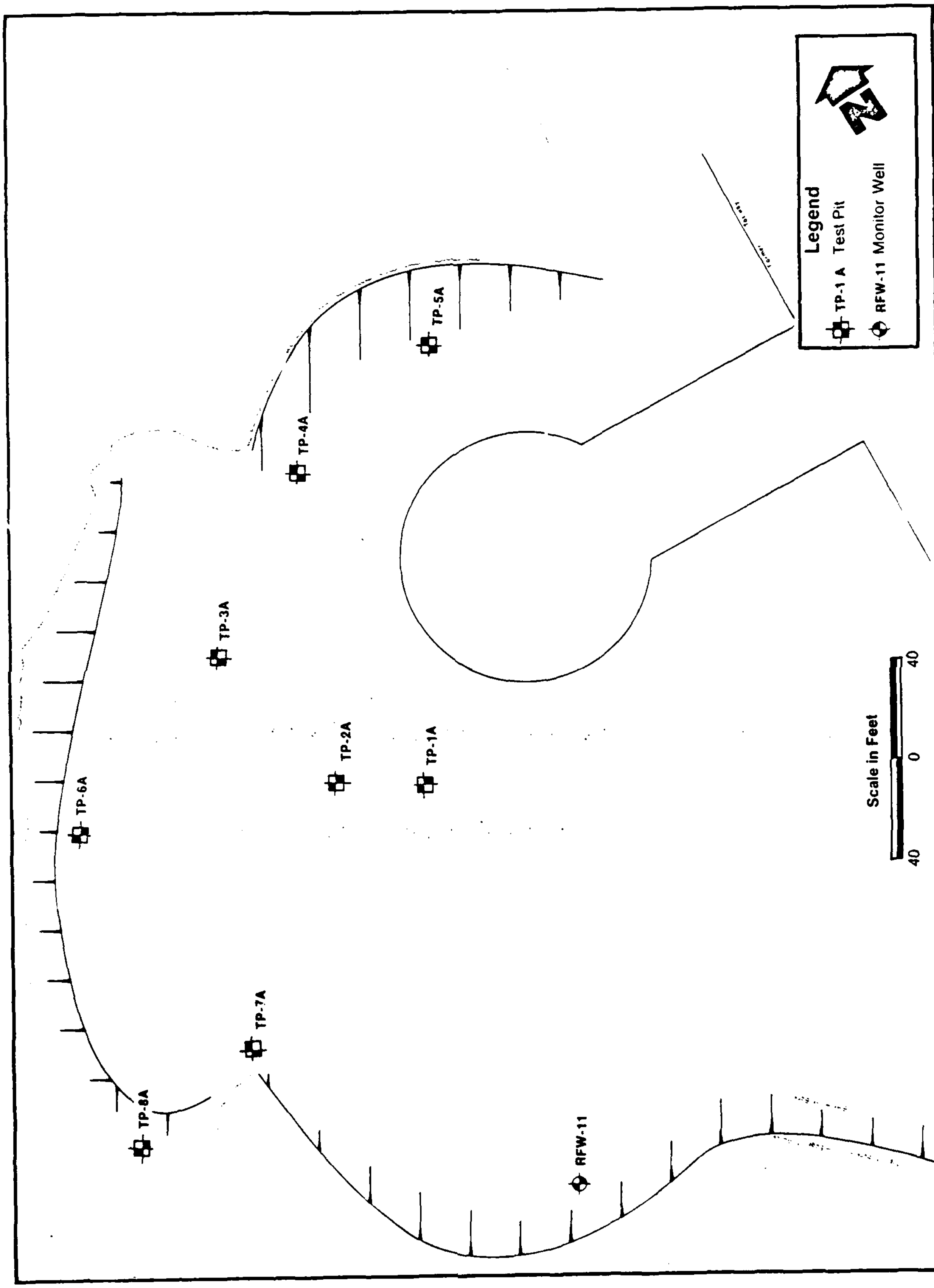

FIGURE 3-5 MAP OF AVGAS FUEL TEST DUMP SITE SHOWING WELL AND TEST PIT LOCATIONS

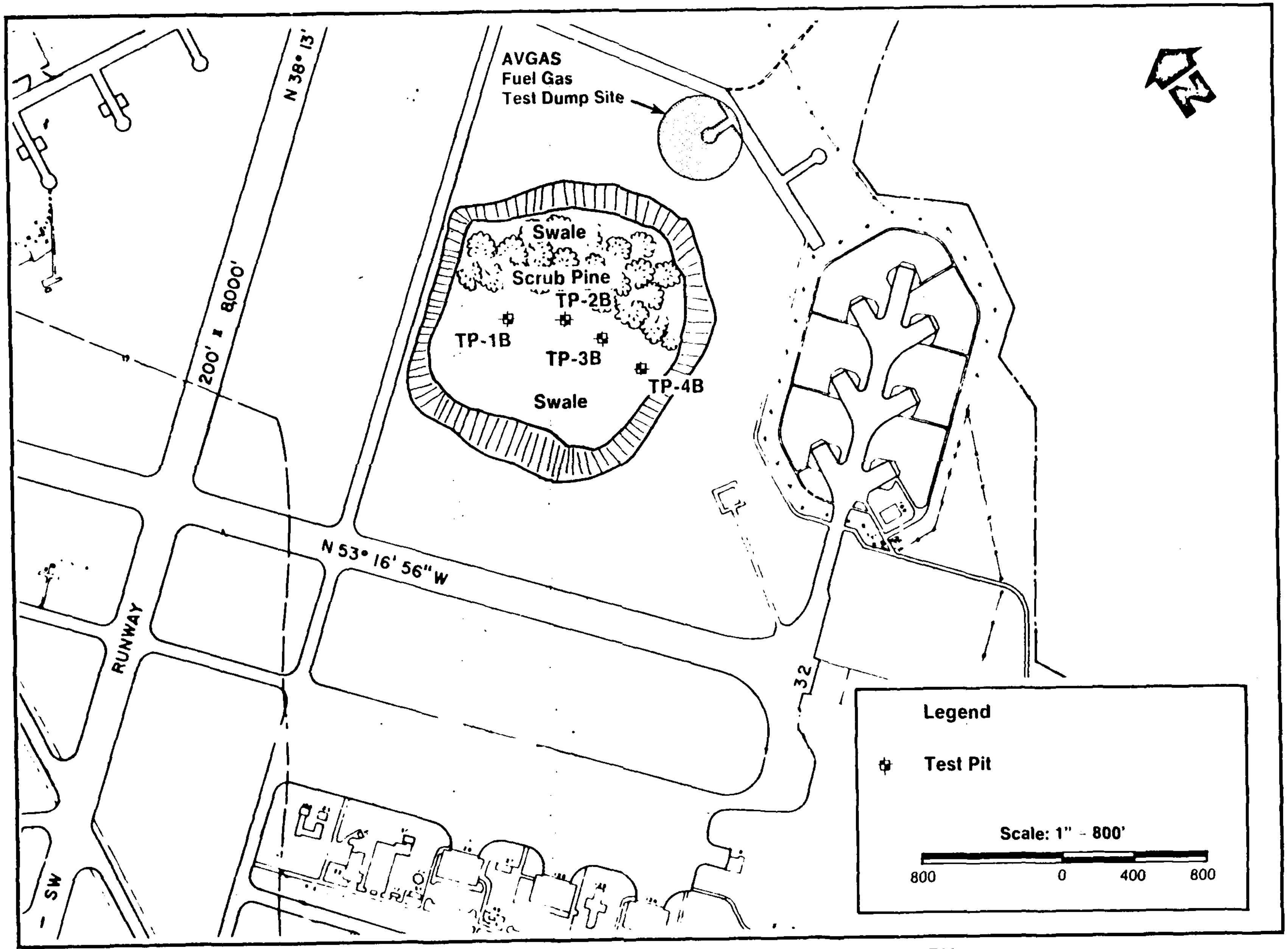

FIGURE 3-5-1 APPROXIMATE LOCATION OF SUPPLEMENTARY TEST PITS SOUTH OF AFTDS

in order to detect residual hydrocarbon product which might be floating on the water table. HNu readings were taken during the exploratory drilling for this well. Its location is shown on Figure 3-5.

3.2.1.5 Railyard Fuel Pumping Station (RFPS)

A total of 18 test pits were excavated at the former RFPS, one adjacent to each of 15 header pipes along an abandoned railroad bed (TP-1 through TP-15), and an additional 3 (TP-16 through TP-18) in the vicinity of the former pumphouse. Figure 3-6 illustrates the locations of these test pits. The test pits were excavated to monitor near-surface evidence of former fuel spillage in and around the loading racks and pumping station. An HNu meter was used to obtain field evidence of volatile components in the soil. Four soil samples were collected for analysis.

Two wells (RFW-8 and RFW-9) were installed downgradient of the RFPS at locations shown on Figure 3-6. These wells were constructed into the uppermost portion of the aquifer to monitor potential effects of Avgas and JP-4 spillage. During exploratory drilling, split-spoon soil samples were screened with an HNu meter.

3.2.1.6 Petrol Fuel Storage Area (PFSA)

One well was installed downgradient of the current Petrol Fuel Storage Area. This area historically has stored Avgas and JP-4 and is currently storing heating oil and JP-4. Therefore, the downgradient well shown on Figure 3-7 was constructed to monitor the uppermost zones of saturation. The well screen extends several feet above static water level to detect the presence of floating hydrocarbons. During the exploratory drilling, split-spoon samples were monitored for volatile organics with an HNu meter.

3.2.2 Field Testing

In order to maximize data collected from each of the test pits and monitor wells installed, various field testing techniques were employed. The field testing program involved: surveying locations and top-of-casing elevations of all monitor wells to provide water level elevation control; surveying of ground elevations and locations of the CFTA, AFTDS and RFPS test pits; water level measurements in all wells to provide hydrogeologic and hydraulic gradient

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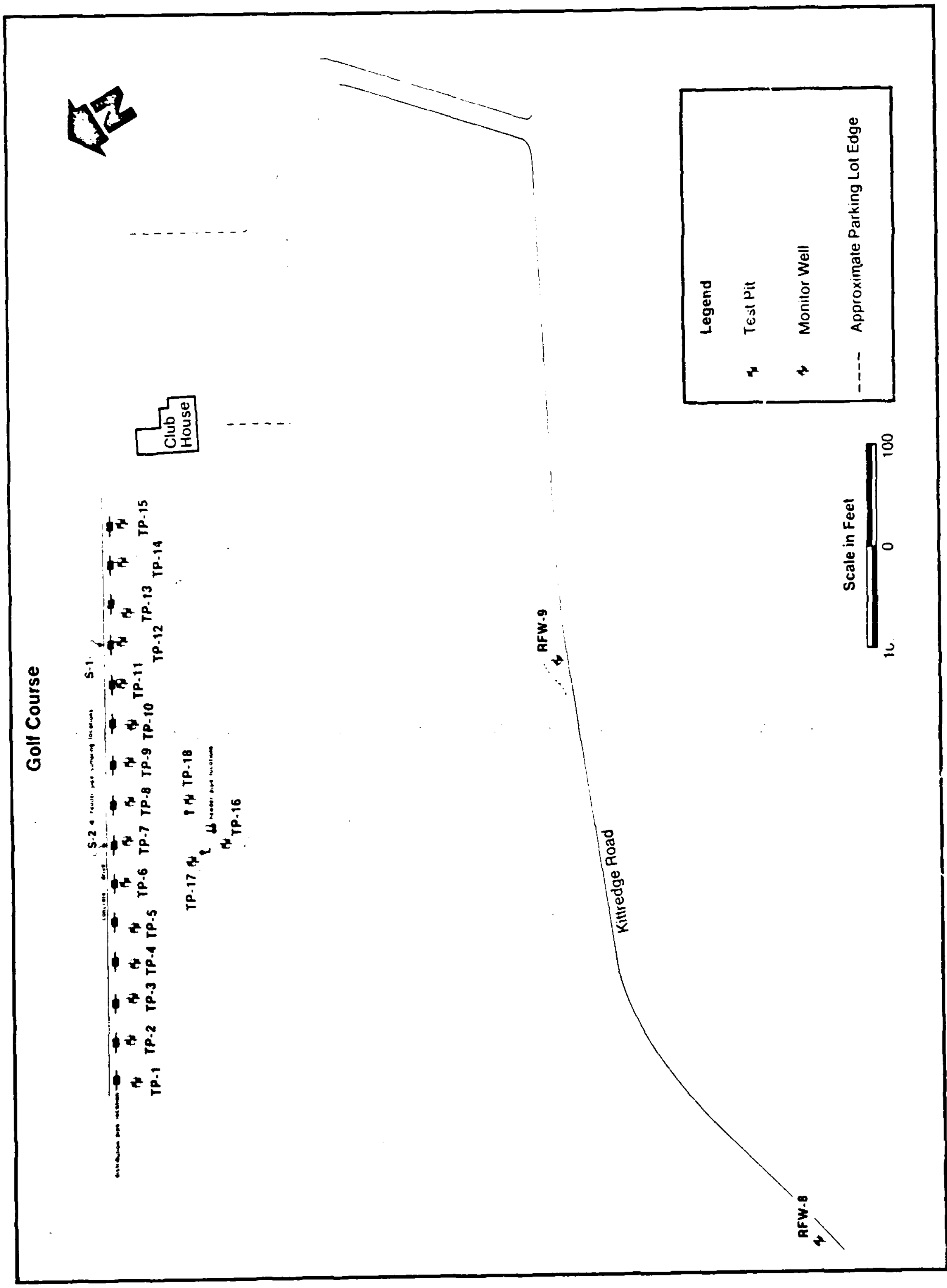

FIGURE 3-6 MAP OF RAILYARD FUEL PUMPING STATION SHOWING WELL AND TEST PIT LOCATIONS

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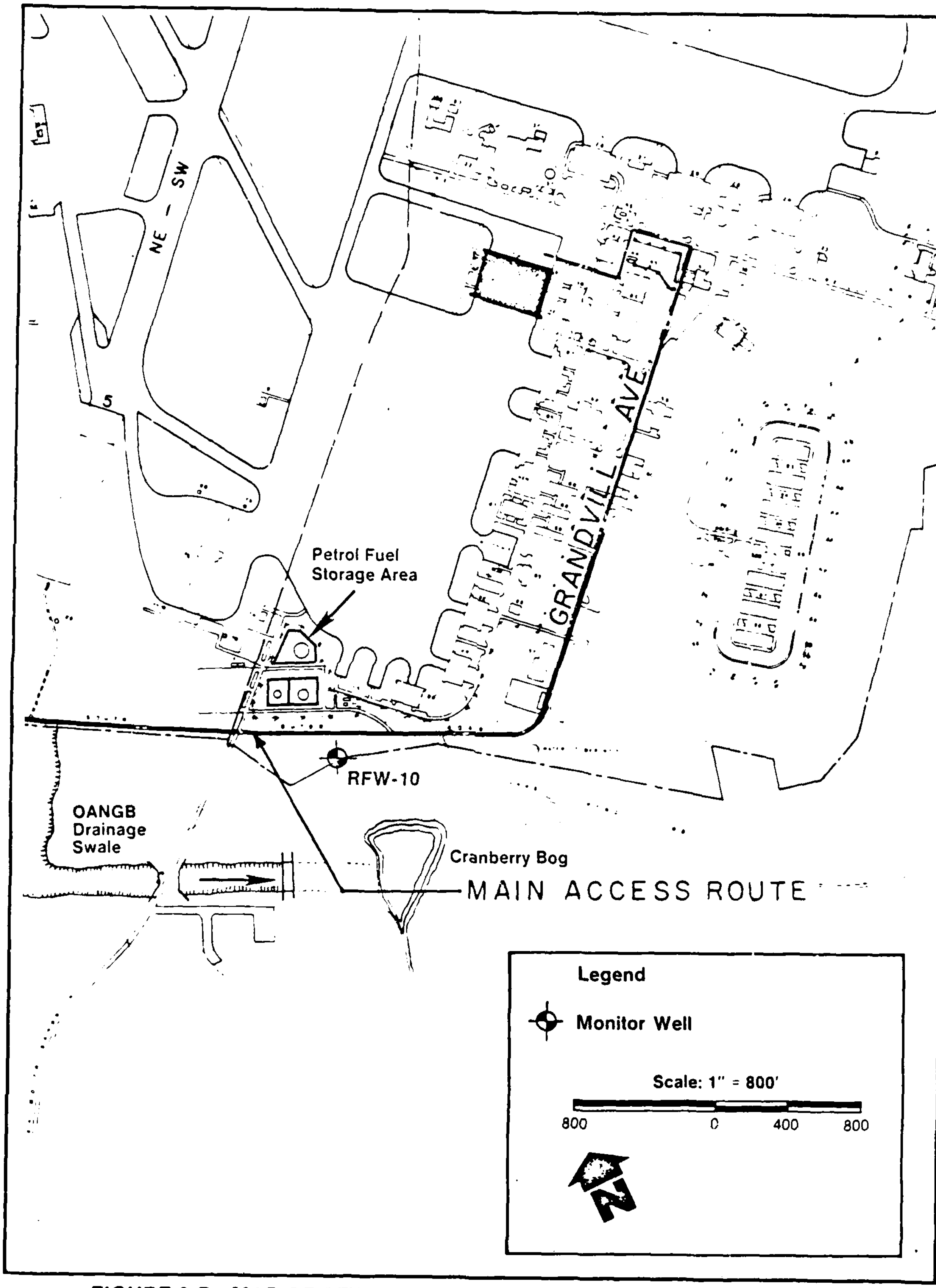

FIGURE 3-7 MAP OF PETROL FUEL STORAGE AREA SHOWING MONITOR WELL LOCATION

data; and field water quality testing to provide pH, temperature, and specific conductance information. Each phase of the field testing is described below.

3.2.2.1 Surveying

On 7 and 8 February 1984 and 17 and 18 October 1984, WESTON engineers finished all field work for a complete survey of the wells and the test pits. A Dietzgen Top-Site 6140 30-second Transit was used for horizontal locations to an accuracy of ±10 feet. A Kern GKO-A Automatic Level was used to determine all elevations to an accuracy of ±0.05 feet. Mean Sea Level (MSL) was used as a Datum for all surveying. The benchmark for the elevations at wells RFW-1, RFW-2A, RFW-3A, and RFW-4 was the centerline of the invert of manhole 41.7, located west of the former location of Building 4120. The "as built" plans list the elevation as 124.70 feet. The benchmark for the CFTA test pits and monitor wells RFW-5 and RFW-6 was the sill elevation for the laboratory building at the wastewater treatment plant. This elevation was taken from plans of the finished building and was listed as 91.0 feet. For well RFW-7, WESTON used benchmark 2 + 10, located southeast of the concrete apron at the southwest end of Runway 5, at an elevation of 110.08 feet. At each well site, including wells RFW-2 and RFW-3, the data recovered included horizontal location, top of PVC casing, top of steel casing, and ground elevation. For the CFTA, AFTDS, and RFPS test pits, location and ground surface elevation were established by survey.

3.2.2.2 Water Level Measurements

Following completion of wells RFW-1 through RFW-7 in January 1984, a round of water table elevation measurements was made using a Soil Test Model DR-760A Water Level Probe. Prior to sampling the wells, on 7 and 9 February 1984, a second round of water level measurements was taken. During the second round of water level measurements, replacement wells RFW-2A and RFW-3A were used in lieu of wells RFW-2 and RFW-3, respectively. After the additional wells (RFW-8 through RFW-11) were installed, a complete round of water level measurements was made on 11 and 17 October 1984. Table 3-5 provides a summary of monitor well survey data.

TABLE 3-5

Summary of Monitor Well Survey Data

Site	Well	1/14/84	2/7/84	2/9/84	2/23/84	10/11/84	10/17/84	11/7/84	Elev. Top of Casing (ft)
				Depth to Water (feet)					
Base Landfill	1	76.40	73.34	73.28	73.31	70.51	70.71	71.01	132.98
	2A	-	73.59	73.48	73.61	71.16	71.08	71.42	135.79
	3A	-	82.81	82.62	82.78	80.12	80.00	80.03	146.16
	4	71.81	72.79	71.84	71.94	69.30	69.19	69.57	135.50
CFTA	5	55.92	59.25	59.04	58.97	57.38	57.75	58.11	109.91
	6	55.01	58.12	58.26	57.97	56.50	56.79	57.24	109.17
FFTA/NDI	7	41.92	41.72	41.72	41.69	40.51	40.28	41.18	100.00
RFPS	8					41.79	43.25	43.66	95.45
	9					47.79	48.67	48.88	101.36
PFSA	10					52.79	53.92	53.96	102.97
AFTDS	11					48.51	47.25	47.67	108.69
				Groundwater Elevation (feet)					
Base Landfill	1	56.58	59.64	59.70	59.67	62.47	62.27	61.97	
	2A	--	62.20	62.31	62.18	64.63	64.71	64.37	
	3A	--	63.35	63.54	63.38	66.04	66.16	66.13	
	4	63.69	62.71	63.66	63.56	66.20	66.31	65.93	
CFTA	5	53.99	50.66	50.87	50.94	52.53	52.16	51.80	
	6	54.16	51.05	50.91	51.20	52.67	52.38	51.93	
FFTA/NDI	7	58.08	58.28	58.28	58.31	59.49	59.72	58.82	
RFPS	8					53.66	52.20	51.79	
	9					53.57	52.69	52.48	
PFSA	10					50.18	49.05	49.01	
AFTDS	11					60.18	61.44	61.02	

3.2.2.3 Field Water Quality Testing

From 7 through 9 February 1984, a total of 12 samples were collected at Otis ANGB. The samples included groundwater samples from seven wells, including two duplicate samples, and one trip blank, as well as one water and one sludge sample from a drain sump at the NDI.

During the sampling program, field testing for pH, temperature, and specific conductance was performed at monitor wells RFW-1, RFW-2A, RFW-3A, RFW-4, RFW-5, RFW-6, and RFW-7. To assess water quality changes with depth, readings for the three parameters were taken at 10, 20, 30, and 40 feet from the bottom of each well. A Yellow Springs Instrument Company Model 33 SCT Meter was used to measure specific conductance and temperature. An Analytical Measurement Model 107 pH Meter was used to record the pH of groundwater samples.

Table 3-6 contains a complete list of all field water quality testing data for wells RFW-1 through RFW-7.

During the week of 5 November 1984, wells RFW-1 through RFW-11 were sampled; RFW-8 through RFW-11 were sampled for the first time. Duplicates and blanks were also collected for quality control. On 13 December 1984 the two header pipes at the loading rack of the RFPS were sampled as described below. Field testing for pH, temperature, and specific conductance was performed on all wells during the course of the drilling and the field sampling tasks. The combined results of the additional field testing conducted after February 1984 are presented in Table 3-6-1.

3.2.3 Pipe and Fuel Sampling

On 13 December 1984, WESTON personnel collected liquid samples from pipes at the Railyard Fuel Pumping Station (RFPS). It was not possible to obtain a sample from any of the transmission lines. Two lines were found to be dry at the access point. The third line contained liquid. Three elbows (bends) in the pipe prevent this liquid from being sampled. Therefore, samples were taken from each of two header pipes (numbers 7 and 12).

Samples were pumped from the header pipes with an ISCO Model pump and polypropylene tubing. New tubing was used at each header and the pump was decontaminated with distilled water after each sample was taken. Each sample was collected in two 1-liter amber glass bottles with teflon-lined lids and in two 40-milliliter volatile organic vials with teflon-

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TABLE 3-6

Field Groundwater Quality Test Results with Depth

Well No.	Date	Approx. Elevation of Sample (MSL)	pH	Parameter Temperature °C	Specific Conductance (umhos/cm)
RFW-1	2/7/84	13 (deepest)	6.0	12	140
		23	6.2	12	142
		33	6.0	12	142
		43	6.0	12	140
		53 (shallowest)	6.0	11.5	140
RFW-2A	2/7/84	22	5.0	12	45
		32	5.0	12	45
		42	5.2	12	50
		52	5.2	[illegible]	45
		62	5.2	[illegible]	48
RFW-3A	2/7/84	22	5.2	[illegible]	48
		32	5.0	[illegible]	[illegible]
		42	5.0	[illegible]	[illegible]
		52	5.1	[illegible]	48
		62	5.0	[illegible]	48
RFW-4	2/8/84	22	6.0	9	[illegible]
		32	6.0	9	[illegible]
		42	6.0	9	[illegible]
		52	6.1	10	[illegible]
		62	6.1	10	[illegible]
RFW-5	2/8/84	6	5.2	10	45
		16	5.2	10	45
		26	5.2	10	45
		36	5.0	10	45
		46	5.0	10	[illegible]
RFW-6	2/9/84	10	5.4	[illegible]	[illegible]
		20	5.6	[illegible]	[illegible]
		30	5.5	[illegible]	[illegible]
		40	5.4	[illegible]	[illegible]
		50	5.6	[illegible]	[illegible]
RFW-7	2/8/84	[illegible]	5.5	[illegible]	[illegible]
		13	5.4	[illegible]	[illegible]
		23	5.4	[illegible]	[illegible]
		33	5.4	[illegible]	[illegible]
		43	5.5	[illegible]	[illegible]

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TABLE 3-6-1

Summary of Groundwater Quality Test Reports

Well No.	Temperature °C 7-8 Feb 84			Specific Conductance, umhos/cm 7-8 Feb 84			pH, s.u. 7-8 Feb 84		
	7-8 Feb 84	11-12 Oct 84	6-8 Nov 84	7-8 Feb 84	11-12 Oct 84	6-8 Nov 84	7-8 Feb 84	11-12 Oct 84	6-8 Nov 84
1	11.5	11.6	10.0	140	81	198	6.0	6.45	6.2
2A	12.0	13.9	11.0	45	48	60	5.2	5.95	4.6
3A	12.0	13.8	11.5	48	58	90	5.0	5.35	5.0
4	10.0	13.2	10.5	38	55	68	6.1	5.50	4.9
5	10.0	13.5	10.0	45	45	65	5.0	5.35	6.0
6	11	13.5	10.0	38	38	65	5.6	5.35	5.8
7	11	12.5	10.0	58	65	88	5.4	5.70	4.8
8	--	13.0	9.0	--	15	52	--	5.80	7.4
9	--	13.0	9.5	--	30	70	--	5.75	7.4
10	--	14.0	12.0	--	90	75	--	6.20	6.4
11	--	9.2	8.5	--	27	42	--	7.05	5.0

coated septa. After the samples were collected, they were placed in an ice-filled cooler and packed for shipping to WESTON's laboratory for analysis of lead, hydrocarbons (by GC scan), and base/neutral- and acid-extractables (EPA Method 625). Appropriate sampling protocol and EPA chain-of-custody were followed throughout the sampling procedure.

While WESTON personnel were collecting samples from the header pipes, Otis ANGB personnel collected samples of Mogas, Avgas, JP-4, diesel fuel, and heating oil from tanks on Base. These samples were also shipped to the WESTON laboratory to be used in "fingerprinting" contaminants found during the groundwater sampling program.

On 23 July 1985, the header pipes were resampled for acid and base/neutral compounds since the December 1984 samples exceeded recommended holding times. The samples were bailed with a glass bailer. All other sampling procedures followed the December 1984 protocols.

3.2.4 Water Quality Sampling

The purpose of the water quality sampling program was to identify, insofar as possible at the level of a confirmation survey, the location, concentration and areal extent of any contamination present in the hydrogeologic environment attributable to former disposal practices and operations involving hazardous substances at the identified site. To achieve these goals efficiently, specific field procedures were developed for purging the wells, collecting samples, and ensuring field quality control. These procedures have been used to obtain representative samples for chemical analysis from the monitor wells, soil samples, supernatant and sludges in the NDI sump tank, and liquids in the header pipes at the RFPS. A safety plan developed in conjunction with the sampling is contained in Appendix E. Sample chain-of-custody documentation is contained in Appendix F. Standard laboratory analysis protocols used in the analysis of these samples are contained in Appendix G. Water samples were collected between 7 and 9 February 1984 from RFW-1 through RFW-7, and between 5 and 10 November 1984 from RFW-1 through RFW-11.

On 16 and 17 April 1985, resampling of wells RFW-1 through RFW-7 was undertaken for total organic carbon (TOC) and priority pollutant volatile organics. This was performed to meet EPA recommended holding times between sampling and

analyses as well as respond to concerns of anomalously high TOC levels in the February, 1984 samples and the presence of low levels trichloroethylene (10 ug/L) in all of the November, 1984 samples. On 23 July 1985 resampling at the Base Landfill was performed (RFW-1, RFW-2A, RFW-3A and RFW-4) for sulfate, chloride, nitrate-nitrogen,and pesticide/herbicide and PCB analyses in order to conform to recommended holding times between sampling and analyses. WESTON collected a resample of the supernatant in the NDI sump tank for a lead analysis. The header pipes at the Railyard Fuel Pumping Station were also resampled for acid and base/neutral organic compounds. Results of the water quality sampling program are discussed, along with the hydrogeologic data obtained in the drilling and water level survey program, in the following section.

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SECTION 4

RESULTS

4.1 SITE INTERPRETIVE GEOLOGY

A review of available geologic data obtained during the Records Search and subsequent on-site data generated during the Phase II investigation revealed that Otis ANGB is underlain by a thick, homogeneous sequence of glacial outwash deposits. Split-spoon samples from 11 monitor wells, which ranged in depth from 60 to 130 feet, characteristically contained fine to coarse sand with varying amounts of gravel. Bedrock is reportedly found at depths of 250 to 300 feet and was not encountered in any of the exploratory borings.

The lithology of the sandy Moraine deposits on the northwest portion of the Base (Figure 2-1) and that of the outwash area are virtually the same. No obvious distinctions could be made between the depositional character or stratigraphic changes in the sediments encountered and sampled during drilling. For example, the log for RFW-3, which was drilled to a depth of 130 feet, typically reads: "Tan, medium to coarse SAND, little fine to medium Gravel; loose, dry to damp," through the entire profile.

Silt lenses, or zones where significant permeability contrasts might occur, were not detected in any of the borings. The split spoon sampling was not able to detect the percentage of cobbles and boulders in the sandy to gravelly soils. Based on observations in test pits and deep fill trenches at the Base Landfill, cobbles and boulders are occasionally to frequently present, at least in the upper horizons (down to 25 feet).

4.1.1 Geologic Findings - Current Fire Training Area

The surficial geology of the CFTA was defined by nine test pits and two borings (RFW-5 and RFW-6). Borings RFW-5 and RFW-6 penetrated to depths of approximately 105 feet below land surface (Table 3-4). The test pits excavated at this site revealed a layer of fine sand and clayey silt with embedded gravel, generally occurring between 1 and 2 feet

below land surface. Beyond this soil horizon, the sands were fine to coarse grained and permeable.

The fine sand and clayey silt layer encountered in the test pits at the CFTA originally appeared to have been man-made, placed and compacted as an access ramp to the site; however, its depth and its presence in perimeter test pits suggests it is of natural origin. This low permeability stratum was also observed in test pits at the Railyard Fuel Pumping Station, but not in other test pits at other sites. Fine-grained materials were not observed at greater depths in the split-spoon samples from RFW-5 and RFW-6.

4.1.2 Geologic Findings - FFTA/NDI

Four test pits were excavated at the NDI site. Test pits TP-19 and TP-20 were completed in clean granular fill material below the NDI lab; shallow test pits TP-21 and TP-22 were excavated to 1.5 feet in depth in the swale which conveys runoff from the airfield and northern portions of the Base (Figure 2-2) to the southern Base perimeter. The four test pits indicated that the original ground surface had been cut and filled in the NDI area. The full extent of clean earth backfill could not be ascertained due to the limited extent of excavation. The probable area of disturbance (cut and fill) is illustrated in Figure 4-1. Figure 4-1 also shows the approximate test pit locations in the Former Fire Training Area south of the NDI lab site. These test pits were excavated in an attempt to delineate the specific boundaries of the FFTA. It was expected that this could be accomplished by visual inspections of soil staining and organic vapor monitoring with the HNu meter. In fact, burned trash and solid waste (burnfill) as much as 10 feet in depth were observed in pits TP-25, TP-26, TP-27, TP-28, TP-31 and TP-33. The approximate area containing burnfill debris is illustrated in Figure 4-1. The deposits consisted of cinders, bottles, burned municipal refuse, and metal scrap. Clean fill deposits were noted in and around TP-23, TP-24, TP-29 and TP-32 (see test pit logs - Appendix D). Natural sandy deposits were present in test pit TP-30; these might be clean fill also. As a result of field observations during the test pit investigation, no specific area attributable to former firefighting activities could be clearly discerned from the field observations. However, as a result of soil analysis obtained later, a possible site was identified at TP-26 (Figure 4-1). The analytical

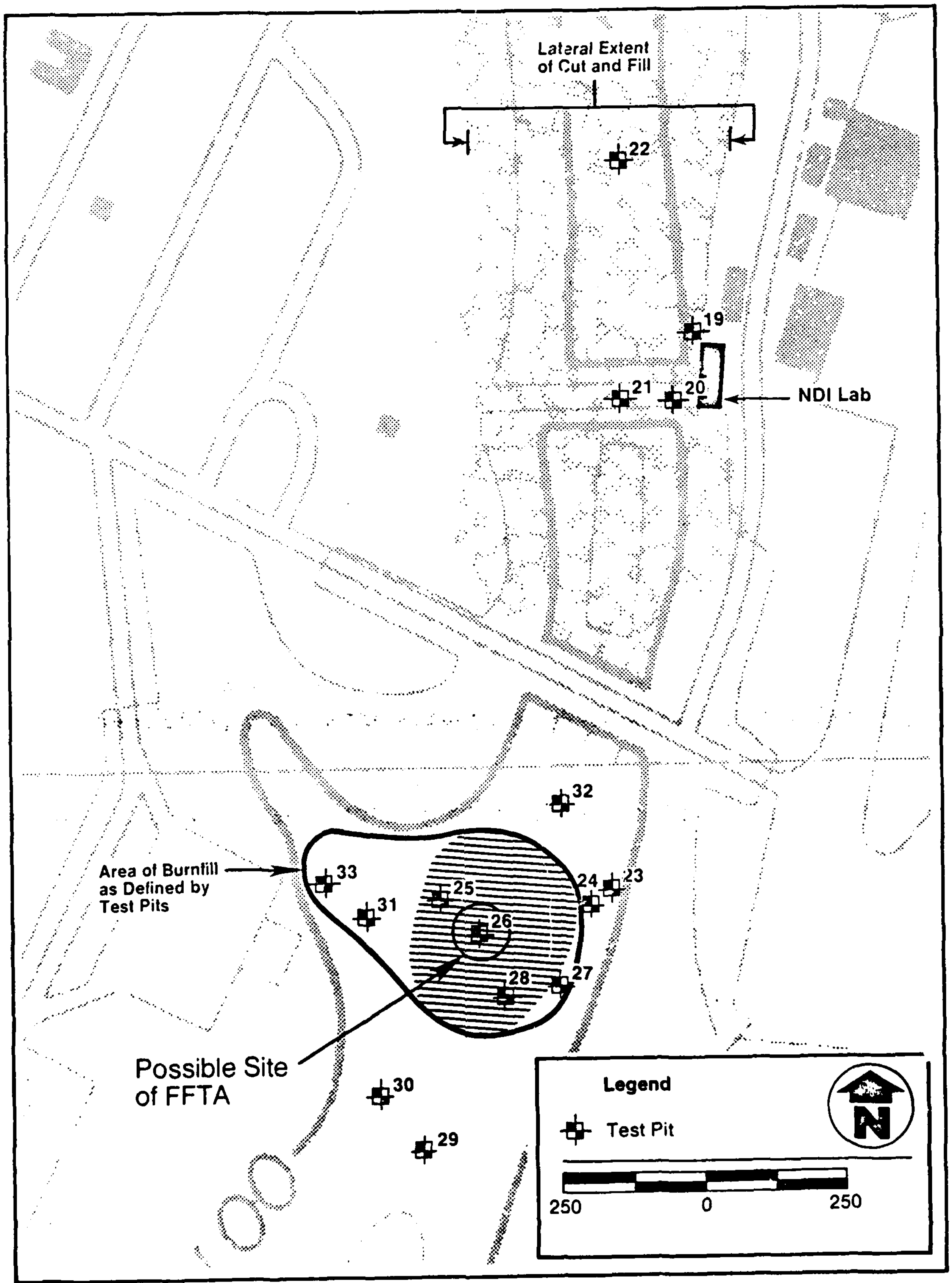


FIGURE 4-1 MAP OF FFTA/NDI SHOWING REFINED BURNFILL AND FFTA SITE

results for a soil sample collected in this area are discussed in Subsection 4.3.2.2 of this report.

4.1.3 Geologic Findings - Base Landfill

The test pit investigation at the Base Landfill was used to delineate the site boundaries. The test pit investigation preceded final monitor well site selection at the Base Landfill. Test pits TP-1 and TP-2 showed burnfill deposits on the northwestern portion of the site to be only 5 to 10 feet thick. Unburned refuse was encountered in Test Pits TP-4, TP-5, and TP-6 to a maximum depth of 5 feet. No deep trenches of refuse were penetrated, although a large area between TP-4 and TP-1 was not investigated. Area fill operations have occurred over wide portions of the Base Landfill. The site, as redefined by test pits and field observations, is shown in Figure 4-2. Figure 4-2 also illustrates the approximate location of several waste sites within the landfill area. Based on the four borings (RFW-1 through RFW-4) drilled to depths between 120 and 130 feet around the downgradient side of the landfill, refuse is underlain by extensive fine to coarse sand with little gravel. This was also apparent in the new trench (Figure 4-2) and the gravel pits in and around RFW-4.

4.1.4 Geologic Findings - Avgas Fuel Test Dump Site

Test pits TP-1A through TP-8A were installed in the immediate area of the AFTDS (Figure 3-5). Remote downgradient pits were installed in a drainage swale south of the suspect site. The test pits extended to a depth of 10 feet and encountered coarse sands and gravels in the vicinity of the AFTDS. The AFTDS area has been used as a borrow pit for sand and gravel; therefore, no topsoil layer was evident in these pits.

A dark oily layer was observed in TP-3A at approximately 8 inches and black sand and gravel were encountered from 2 to 6 feet in TP-6A. A 1/2-inch thick black layer was observed in TP-8A at 2 feet and bands of black discolored gravel were observed from 1 to 5.5 feet in TP-7A. However, field screening for organics with an HNu revealed no detectable volatile organics in these discolored soils. Samples of the discolored soils from these pits were collected for laboratory analysis. These results will be discussed later in this report.

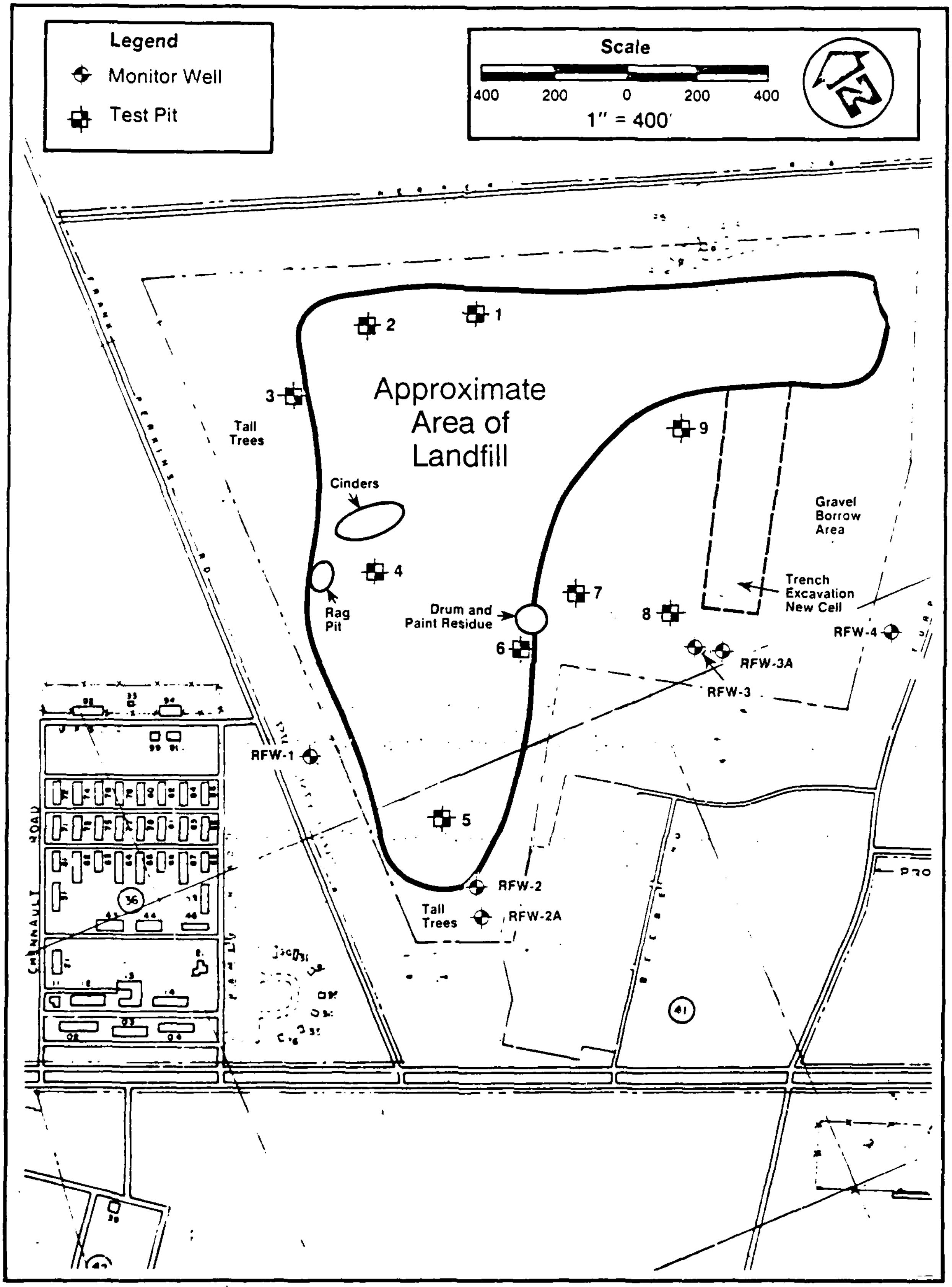


FIGURE 4-2 MAP OF BASE LANDFILL AS REDEFINED BY TEST PITS

Test pits TP-1B through TP-4B conducted in the swale south of the site (Figure 3-5-1) contained coarse sands and gravels similar to those encountered at the AFTDS. A thin layer of peat was observed at a depth of 7 feet in test pits TP-2B and TP-3B indicating a former swampy organic environment of minimal lateral extent. The swamp probably was present at land surface during the depositional time of these outwash sands and gravels.

The exploratory drilling and soil sampling from RFW-11, installed at the AFTDS, showed that the sands and gravels are uniform to a depth of at least 60 feet beneath the site. These permeable outwash deposits were found to be dry to the water table which was encountered at approximately 45 feet below land surface.

4.1.5 Geologic Findings - Railyard Fuel Pumping Station

Test pits TP-1 through TP-18 and RFW-8 and RFW-9 were installed at the RFPS to assess the surficial soil and hydrogeological conditions in this area (Figure 3-6).

Based on the test pit investigation, the soil material throughout the area consisted primarily of a thin layer of topsoil underlain by medium to coarse sands and gravel. A discontinuous hardpan layer common to the podzol soils of the region was encountered in several of the test pits (Appendix D). A gray layer of silt and fine sand with embedded pebbles was observed in TP-6 through TP-18. The fine-grained layer generally occurred between 2 and 6 feet below land surface and ranged from discontinuous layers (2 inches) to massive (6 feet) in TP-17. These observations were similar to those made at the CFTA.

There were no noticeable odors or evidence of stained soil in test pits TP-1 through TP-15. There was a black stained soil in test pits TP-16 through TP-18 (Figure 3-6). The stained soil was generally confined to the upper two feet of the excavation. Layers of oxidized sand and gravel were frequently noted throughout the test pit profile. HNu readings remained at background levels during the test pit work. Soils from test pits TP-1, TP-9, TP-14, and TP-16 were collected for analysis. Analytical results are discussed in Subsection 4.3.5.1 of this report.

Wells RFW-8 and RFW-9 were installed along Kittredge Road south of the RFPS. The wells were drilled to 59 and 61 feet

below land surface respectively. Split-spoon samples, collected at 10-foot intervals, consisted of sand and gravels of outwash origin similar to those at other sites. Tan, medium to coarse sands with some fine to medium gravel were penetrated in each boring. The clean sands and gravels represent the outwash deposits described in Section 2 of this report. No geologic field evidence of an ongoing source of contamination was observed in the exploratory boring program at the RFPS.

4.1.6 Geologic Findings - Petrol Fuel Storage Area

Well RFW-10 was installed as a remote downgradient monitor well for the PFSA. The well was drilled to a total depth of 71 feet. It penetrated light brown fine to coarse sands with some fine to medium gravels. An HNu meter was used to detect fuel odors in the exploratory borings. No evidence of fuel contamination was detected in split-spoon soil samples above the water table. Fuel odors were detected as the exploratory drilling reached the water table approximately 52 feet below land surface. An HNu reading of 12 parts per million above background was detected in soil-water sample S-8 collected at 60 feet below land surface. The water quality results are discussed in Subsection 4.3.5.3 of this report.

Geologically, RFW-10 indicates this area is underlain by permeable outwash deposits similar in lithology to the deposits encountered during drilling at the other Phase II study sites.

4.2 SITE GROUNDWATER CONDITIONS

The unconsolidated deposits beneath Otis ANGB comprise a prolific unconfined aquifer with depths to the water table ranging from approximately 40 to 80 feet below ground surface. Water table elevations vary from about 63 feet above mean sea level (MSL) at the Base Landfill to about 50 feet MSL near the Sewage Treatment Plant.

Figure 4-3 illustrates the approximate water table configuration and groundwater flow patterns beneath Otis ANGB in November 1984. This map is based on measurements from the 11 monitor wells installed as part of the Phase II study and reported in Table 3-5.

4.2.1 Groundwater Flow Directions

Figure 4-3 demonstrates that the regional groundwater flow beneath Otis ANGB is generally to the south under very low

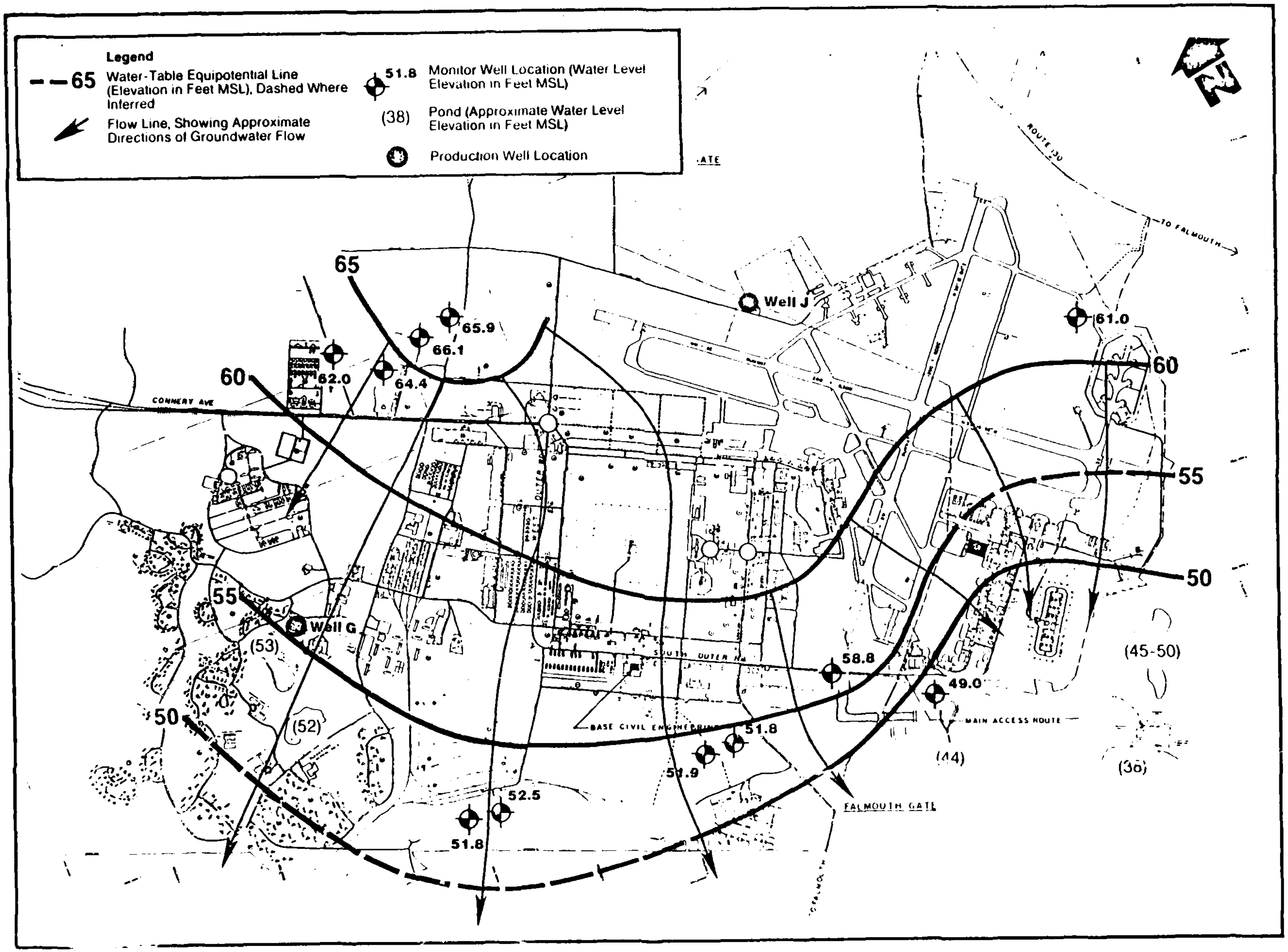
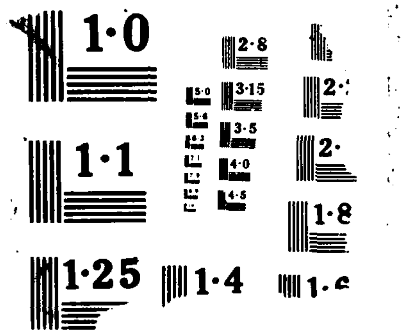


FIGURE 4-3 APPROXIMATE WATER TABLE MAP OTIS AIR NATIONAL GUARD BASE NOVEMBER, 1984

AD-A194 972 INSTALLATION RESTORATION PROGRAM PHASE 2 CONFIRMATION/QUANTIFICATION STAG..(U) WESTON (ROY F) INC WEST CHESTER PA R L KRAYBILL ET AL. 04 SEP 85 2/2

UNCLASSIFIED F33615-80-D-4006 F/G 24/4 NL


1·0
2·8
3·15
3·5
4·0
4·5
1·1
1·8
1·25
1·4

gradients. Based upon the water table map of November 1984, groundwater flows south-southeast from areas on the eastern side of the Base, and south or south-southwest from areas on the west side of the Base. This is consistent with the regional water table map in Figure 2-4, which shows Otis ANGB to be located on a zone of groundwater flow divergence near the top of a regional recharge mound. This is demonstrated by the water levels in the wells downgradient of the Base Landfill, which indicate that groundwater flows toward the southwest from the western side of the landfill and towards the southeast from the eastern side. It should be noted that this analysis is based on data from a limited number of wells.

Flow directions in the vicinity of the fire training areas (CFTA and FFTA) were determined by reviewing water table depths in the Phase II monitor wells, existing regional flow maps, and data on local pond elevations. In general, groundwater flows beneath these areas to the south. The average horizontal gradient measured between RFW-3A and RFW-5 was computed to be 0.001; hydraulic gradients of up to 0.003 are indicated by the water table map (Figure 4-3). An average horizontal groundwater gradient of 0.002 for the area of Otis ANGB appears to be representative.

According to LeBlanc (1982), vertical hydraulic gradients are not apparent in the multilevel wells installed by the USGS south of Otis ANGB. This was one reason why multilevel wells were not initially installed at Otis ANGB. Field test results of specific conductivity presented in Table 3-6 do not show evidence of significant water quality contrasts with depth. This, coupled with the homogeneity of the aquifer, suggests that significant vertical hydraulic gradients do not exist beneath Otis ANGB.

4.2.2 Groundwater Flow Rates

The performance of in situ slug and recovery testing was beyond the scope of this study. However, preliminary tests of this nature were conducted during well development. They revealed high hydraulic conductivities which could not be precisely computed due to extremely rapid recovery rates in the wells. Studies by Leblanc (1982) indicate hydraulic conductivities of from 200 to 300 feet per day. This is consistent with the observations made during well development. Hydraulic conductivity is a measure of permeability given in units of velocity, and is defined as the volume of water

flowing through a given cross sectional area of an aquifer in a given time period under a unit hydraulic gradient. The actual rate of flow is given by the equation:

$$V_s = \frac{Ki}{Ne}$$

where V_s = Actual linear flow velocity (L/T)
K = Average hydraulic conductivity (L/T)
i = Hydraulic gradient (dimensionless)
Ne = Effective porosity (dimensionless)

Assuming an effective porosity of 0.30, a hydraulic conductivity of 200 to 300 feet/day, and a computed hydraulic gradient between 0.001 and 0.002, the estimated actual flow velocity through the aquifer is approximately 1 to 2 feet per day, or 300 to 700 feet per year.

Computations of travel times for groundwater quality constituents to installation boundaries from the sites of major concern are speculative, especially where flow conditions are not definitive. Such travel times are also a function of constituent concentration, density, solubility, and reactivity with the aquifer matrix, among other parameters. In general, a conservative estimate of travel times is obtained by assuming that constituents dissolved in groundwater travel at the same rate as groundwater, without any retardation from constituent or matrix effects. At a flow rate of 300 to 700 feet per year, water quality constituents from the Base Landfill may have reached the installation boundaries. However, dispersion and dilution from infiltrating rainfall and mixing with the vast amount of water in storage most likely would greatly reduce the concentration of any constituents reaching the groundwater flow system from the landfill.

Due to their close proximity to installation boundaries, the CFTA, FFTA/NDI, RFPS, and PFSA sites have a greater potential for impact on off-Base groundwater quality. A plume of effluent from the sanitary wastewater treatment plant, located approximately 1,000 feet south of the CFTA, was reported by LeBlanc (1982) to have migrated at least 9,000 feet off-Base in a southerly direction. LeBlanc's findings are consistent with the flow direction and rate estimates made as part of the Phase II study. The conclusions concerning environmental impacts of contaminants

from the suspect sites on local and regional water quality are discussed in the following sections of this report.

In addition to the calculations of linear velocity and flow rate information presented above, a preliminary conclusion as to the volumetric flow through the aquifer was also made, taking into account reported hydraulic conductivities and on-site groundwater gradient data. This information is relevant where there is a need to determine the total volume of contaminated groundwater migrating in the groundwater flow system.

Groundwater discharge is given by the following equation:

$$Q = KiA$$

where K = 250 feet/day - average estimated conductivity
i = 0.001 to 0.002 - range in hydraulic gradient
A = 1 ft^2-cross section of aquifer (where 1 ft^3 =7.48 gallons)

This computes to approximately 2 to 4 gallons per day per square foot of aquifer.

The transmissivity (T) of an aquifer is given by:

$$T = Kb$$

where K = hydraulic conductivity (250 feet/day)
b = aquifer thickness (200 feet of saturated medium-to-coarse sands)

The calculated transmissivity for the regional aquifer is, therefore, 50,000 square feet per day (slightly less than 375,000 gallons per day per foot). According to Freeze and Cherry (1979), transmissivities greater than 100,000 are characteristic of potentially viable water resources.

The interpretation of available flow information generated to date indicates Otis ANGB is underlain by a prolific aquifer under an extremely low hydraulic gradient. This low hydraulic gradient is somewhat misleading, however, since it is offset by a very high aquifer permeability, resulting in high rates of groundwater flow through the aquifer.

The thickness, homogeneity, and lateral extent of the aquifer is such that widespread groundwater contamination can

occur, given a large enough source of pollution. Mitigating that possibility are the large potential dilution factors resulting from proportionately high recharge rates and large volumes of groundwater in storage.

The resultant environmental impacts of suspect contaminants from the ranked sites and the PFSA are considered in the following subsections of this report.

4.3 ANALYTICAL RESULTS

The principal objective of the Phase II, Stage 1 Problem Confirmation Study was to determine whether past hazardous waste operations or disposal practices at a site had resulted in significant environmental impact or confirmable degradation. The analytical results of the Phase II study are based on field testing, sampling of selected soils, liquid supernatant and sludge from a waste tank, header pipes at the RFPS, and newly installed monitor wells. Wells RFW-1 through RFW-7 were sampled twice; RFW-8 through RFW-11 were sampled once.

Tables 3-1 and 3-1-1 present the analytical protocol for each site. Soil analytical results from the 1983 and 1984 soil sampling programs are presented in Tables 4-1 and 4-1-1; analytical results from the 11 monitor wells are given in Table 4-2. Laboratory analyses reports are contained in Appendix I. Appendix J contains a complete listing of Federal and state drinking water and human health standards, criteria and guidelines applicable in the State of Massachusetts.

The original analytical protocol for halogenated organics in the Confirmation Study was restricted to a screening methodology, using total organic halogens (TOX) as the screening parameter. As part of the contract modification, second round sampling for specific volatile priority pollutants in groundwater was authorized. Some discussion regarding the EPA's priority pollutant list and health guidance criteria for priority pollutants is, therefore, in order.

On 28 November 1980, the US Environmental Protection Agency issued criteria for 64 toxic pollutants or pollutant categories which could be found in water. The criteria established recommended maximum concentrations for acute and chronic exposure to these pollutants for both human and aquatic life. The derivation of these exposure values was

TABLE 4-1

Soil Sample Analytical Results

CFTA, NDI, and FFTA

TP No.	Sample No.	Depth of Sample (ft)	HNu Reading (ppm)	Laboratory Results: Oil and Grease ug/g D.L. 1.0 ug/g	Laboratory Results: TOX ug/g D.L. 0.1 ug/g	Laboratory Results: Lead ug/g D.L. 2 ug/g
Current Fire Training Area						
10	10-1	0.5-1.5	1+	2,890	0.11	93
10	10-2	2.5-3.5	Background	58	ND	14
10	10-3	7	Background	202	ND	21
11	11-1	0-2.5	20-50	18,200	0.35	94
11	11-2	4	15-20	285	ND	18
11	11-3	9	3-5	68	ND	29
12	12-1	3.5	10-20	37	ND	14
12	12-2	8.5	2	78	ND	84
13	13-1	4	2	22	ND	30
14	14-1	4	10-15	100	ND	28
Non-Destructive Inspection Laboratory						
21	21-1	0.5-1	Background	313	0.64	110
22	22-2	1-1.5	Background	139	0.46	30
Former Fire Training Area						
26	26-1	2	Background	1,660	0.23	6,880
33	33-1	5.5	Background	135	ND	280

D.L. - Detection Limit
ND - Nothing found above detection limit
NOTE: See Test Pit Logs for additional sampling information

TABLE 4-1-1

Soil Sample Analytical Results, AFTDS and RFPS

			Laboratory Results							
						Volatile Organic Compounds (D.L. 50 ug/kg)			
TP No.	Depth of Sample (ft)	HNu Reading (ppm)	Total Fuel Hydrocarbons D.L. 1 mg/kg	Phenolics D.L. 0.2 ug/g	Lead D.L. 2 ug/g	Methylene Chloride	Acetone	2 Butanone	Chloroform
Avgas Fuel Test Dump Site									
TP-3A	0.5-1	Background	ND	0.3	25.6	-	-	-	-
TP-6A	5	Background	ND	0.4	24	-	-	-	-
TP-7A	1-3	Background	ND	0.5	532	-	-	-	-
TP-8A	2	Background	ND	0.2	27	-	-	-	-
Railyard Fuel Dumping Station									
TP-1	1-2.5	Background	ND	ND	<12.5*	trace	ND	ND	ND
TP-9	4-8	Background	ND	ND	28	1,100	ND	ND	ND
TP-14	1-3	Background	ND	0.2	38.6	trace	52	ND	ND
TP-16	0.5-1	Background	ND	0.3	30.9	810	trace	trace	trace

D.L. - Detection Limit

ND - Nothing found above detection limit

* - Did not meet detection limit

trace - Concentrations found above detection limit but not quantifiable

TABLE 4-2

ANALYTICAL RESULTS
GROUNDWATER MONITOR WELLS

Parameter	Detection Limit & Reporting Unit	RFW-1 2/7/84	RFW-1 11/7/84	RFW-1 4/17/85	RFW-1 7/23/85	RFW-2A 2/7/84	RFW-2A 11/6/84	RFW-2A 4/17/85	RFW-2A 7/23/85
Hardness	2 mg/l	-	25.0	-	-	-	25	-	-
Sulfate	0.5 mg/l	-	*	-	57	-	*	-	6.4
Chloride	5 mg/l	-	*	-	10	-	*	-	9
Nitrate-Nitrogen	0.2 mg/l	-	*	-	N.D.	-	*	-	N.D.
Total Kjeldahl Nitrogen	0.3 mg/l	-	1.6	-	-	-	N.D.	-	-
Ammonia-Nitrogen	0.03 mg/l	-	1.3	-	-	-	N.D.	-	-
TOC	0.1-0.5 mg/l	*	3.0	4.0	-	*	0.6	1.2	-
TOX	5 ug/l	16.4	-	-	-	29.4	-	-	-
Phenol	0.005 mg/l	N.D.	0.007	-	-	N.D.	N.D.	-	-
Oil & Grease	0.1 mg/l	1.03	-	-	-	0.15	-	-	-
IR Scan (Petroleum)	0.5 mg/l	-	6.3	-	-	-	N.D.	-	-
GC Hydrocarbon Scan	1 mg/l	-	-	-	-	-	-	-	-
Nickel	0.1 mg/l	N.D.	-	-	-	N.D.	-	-	-
Arsenic	0.01 mg/l	N.D.	-	-	-	N.D.	-	-	-
Chromium	0.05 mg/l	N.D.	-	-	-	N.D.	-	-	-
Cadmium	0.01 mg/l	N.D.	-	-	-	N.D.	-	-	-
Copper	0.03 mg/l	0.08	-	-	-	N.D.	-	-	-
Cyanide	0.03 mg/l	N.D.	-	-	-	N.D.	-	-	-
Total Dissolved Iron	0.05 mg/l	67.8	32.6	-	-	N.D.	0.11	-	-
Total Lead	0.01 mg/l	N.D.	-	-	-	N.D.	-	-	-
Pesticides/Herbicides	0.2-<10 ug/l	*	-	-	N.D.	*	-	-	N.D.
PCB's	5-10 ug/l	*	-	-	N.D.	*	-	-	N.D.
Detected Priority Pollutant Volatile Compounds (*)									
Carbon Tetrachloride	<2.0 ug/l	-	*	N.D.	-	-	*	N.D.	-
Dichlorodifluoromethane	<4.0 ug/l	-	*	N.D.	-	-	*	11	-
1,4-Dichlorobenzene	<3.0 ug/l	-	*	22	-	-	*	N.D.	-
Methylene Chloride	<2.0 ug/l	-	*	N.D.	-	-	*	4.2	-
1,2-Trans Dichloroethylene	<2.0 ug/l	-	*	7.6	-	-	*	4.2	-
Tetrachloroethylene	<2.0 ug/l	-	*	N.D.	-	-	*	3.5	-
1,1,1-Trichloroethane	<2.0 ug/l	-	*	N.D.	-	-	*	N.D.	-
Trichloroethylene	<2.0 ug/l	-	*	N.D.	-	-	*	18	-
Ethyl Benzene	<2.0 ug/l	-	*	6.4	-	-	*	N.D.	-
Trichlorofluoromethane	<3.0 ug/l	-	*	N.D.	-	-	*	N.D.	-
Additional Organic Compounds (*)									
Total Xylenes	<4.0 ug/l	-	*	N.D.	-		*	N.D.	-
Methyl Ethyl Ketone	<10.0 ug.l	-	*	N.D.	-	-	*	N.D.	-
Methyl Isobutyl Ketone	<4.0 ug/l	-	*	5.3	-	-	*	N.D.	-

NOTES:

1) (-) - Not specified in Analytical Protocol

2) N.D. - Not found above detection limit

3) (*) - Analyses performed but resampled in April, 1985 or July 1985 due to missed holding times, anomalous results, or other QA/QC reason. See Appendix I for all laboratory reports.

4) TOC in blank of February 1984 samples; trichloroethylene in blank of November 1984 samples.

5) Pesticides & herbicides resampled in July, 1985 in Wells RFW-1, RFW-2A, RFW-3A, & RFW-4 due to excessive holding times in February, 1984 samples - No pesticides or herbicides were detected in either round.

TABLE 4-2 (cont.)

ANALYTICAL RESULTS
GROUNDWATER MONITOR WELLS

Parameter	Detection Limit & Reporting Unit	RFW-3A 2/7/84	RFW-3A 11/6/84	RFW-3A 4/17/85	RFW-3A 7/23/85	RFW-4 2/8/84	RFW-4 11/6/84	RFW-4 4/17/85	RFW-4 7/23/85
Hardness	2 mg/l	-	34	-	-	-	20	-	-
Sulfate	0.5 mg/l	-	*	-	5.6	-	*	-	5.5
Chloride	5 mg/l	-	*	-	15	-	*	-	11
Nitrate-Nitrogen	0.2 mg/l	-	*	-	0.4	-	*	-	N.D.
Total Kjeldahl Nitrogen	0.3 mg/l	-	N.D.	-	-	-	N.D.	-	-
Ammonia-Nitrogen	0.03 mg/l	-	N.D.	-	-	-	N.D.	-	-
TOC	0.1-0.5 mg/l	*	1.0	0.7	-	*	0.7	1.7	-
TOX	5 ug/l	15.2	-	-	-	7.6	-	-	-
Phenol	0.005 mg/l	N.D.	N.D.	-	-	N.D.	N.D.	-	-
Oil & Grease	0.1 mg/l	2.0	-	-	-	0.24	-	-	-
IR Scan (Petroleum)	0.5 mg/l	-	N.D.	-	-	-	N.D.	-	-
GC Hydrocarbon Scan	1 mg/l	-	-	-	-	-	-	-	-
Nickel	0.1 mg/l	N.D.	-	-	-	N.D.	-	-	-
Arsenic	0.01 mg/l	N.D.	-	-	-	N.D.	-	-	-
Chromium	0.05 mg/l	N.D.	-	-	-	N.D.	-	-	-
Cadmium	0.01 mg/l	N.D.	-	-	-	N.D.	-	-	-
Copper	0.03 mg/l	0.04	-	-	-	0.04	-	-	-
Cyanide	0.03 mg/l	N.D.	-	-	-	N.D.	-	-	-
Total Dissolved Iron	0.05 mg/l	N.D.	0.15	-	-	N.D.	0.09	-	-
Total Lead	0.01 mg/l	N.D.	-	-	-	N.D.	-	-	-
Pesticides/Herbicides (5)	0.2-10 ug/l	*	-	-	N.D.	*	-	-	N.D.
PCB's	5-10 ug/l	*	-	-	N.D.	*	-	-	N.D.
Detected Priority Pollutant Volatile Compounds (*)									
Carbon Tetrachloride	2.0 ug/l	-	*	N.D.	-	-	*	2.8	-
Dichlorodifluoromethane	4.0 ug/l	-	*	5.9	-	-	*	6.1	-
1,4-Dichlorobenzene	3.0 ug/l	-	*	N.D.	-	-	*	N.D.	-
Methylene Chloride	2.0 ug/l	-	*	6.5	-	-	*	2.0	-
1,2-Trans Dichloroethylene	2.0 ug/l	-	*	N.D.	-	-	*	N.D.	-
Tetrachloroethylene	2.0 ug/l	-	*	N.D.	-	-	*	N.D.	-
1,1,1-Trichloroethane	2.0 ug/l	-	*	N.D.	-	-	*	9.0	-
Trichloroethylene	2.0 ug/l	-	*	N.D.	-	-	*	N.D.	-
Ethyl Benzene	2.0 ug/l	-	*	N.D.	-	-	*	N.D.	-
Trichlorofluoromethane	3.0 ug/l	-	*	N.D.	-	-	*	3.0	-
Additional Organic Compounds (*)									
Total Xylenes	4.0 ug/l	-	*	N.D.	-	-	*	N.D.	-
Methyl Ethyl Ketone	10.0 ug/l	-	*	N.D.	-	-	*	N.D.	-
Methyl Isobutyl Ketone	4.0 ug/l	-	*	N.D.	-	-	*	N.D.	-

NOTES:

1) (-) - Not specified in Analytical Protocol

2) N.D. - Not found above detection limit

3) (*) - Analyses performed but resampled in April, 1985 or July 1985 due to missed holding times, anomalous results, or other QA/QC reason. See Appendix I for all laboratory reports.

4) TOC in blank of February 1984 samples; trichloroethylene in blank of November 1984 samples.

5) Pesticides & herbicides resampled in July, 1985 in Wells RFW-1, RFW-2A, RFW-3A, & RFW-4 due to excessive holding times in February, 1984 samples - No pesticides or herbicides were detected in either round.

TABLE 4-2 (cont.)

ANALYTICAL RESULTS
GROUNDWATER MONITOR WELLS

Parameter	Detection Limit and Reporting Limit	RFW-5 2/8/84	RFW-5 11/8/84	RFW-5 4/16/85	RFW-6 2/9/84	RFW-6 11/8/84	RFW-6 4/16/85	RFW-7 2/8/84	RFW-7 11/8/84	RFW-7 4/17/85	RFW-8 11/7/84	RFW-8 4/16/85	RFW-9 11/7/84	RFW-9 4/16/85
TOC	0.1 - 0.5 mg/l	*	ND	1.1	*	0.7	0.5	*	0.6	0.7	-	-	-	-
TOX	5 ug/l	209.2	-	-	ND	-	-	ND	-	-	-	-	-	-
Phenol	0.005 mg/l	-	ND	-	-	ND	-	-	ND	-	ND	-	ND	-
Oil & Grease	0.1 mg/l	2.29	-	-	0.26	-	-	2.09	-	-	0.16	-	0.13	-
IR Scan (Petrol)	0.5 mg/l	-	ND	-	-	ND	-	-	ND	-	-	-	-	-
Total Lead	0.01 mg/l	ND	-	-	ND	-	-	ND	-	-	ND	-	0.02	-
PCB's	1 ug/l	ND	-	-	ND	-	-	-	-	-	-	-	-	-
GC Hydrocarbon Scan	1 mg/l	-	-	-	-	-	-	-	-	-	ND	-	ND	-
Detected Priority Pollutant Volatile Compounds (*)														
Tetrachloroethylene	<2.0 ug/l	-	*	7.1	-	*	3.0	-	*	ND	*	ND	*	ND
1,2 Trans Dichlor-ethylene	<2.0 ug/l	-	*	ND	-	*	5.6	-	*	ND	*	ND	*	ND
Trichlorethylene	<2.0 ug/l	-	*	2.4	-	*	ND	-	*	ND	*	ND	*	ND
Ethyl Benzene	<2.0 ug/l	-	*	ND	-	*	ND	-	*	ND	*	ND	*	2.8
Additional Organic Compound (*)														
Total Xylenes	<4.0 ug/l	-	*	ND	-	*	ND	-	*	ND	*	ND	*	4.6
Methyl Ethyl Ketone	<10.0 ug/l	-	*	81	-	*	ND	-	*	ND	*	ND	*	ND
Methyl Isobutyl Ketone	<4.0 ug/l	-	*	ND	-	*	ND	-	*	ND	*	ND	*	210

NOTES:

1) (-) - Not specified in Analytical Protocol

2) N.D. - Not found above detection limit

3) (*) - Analyses performed but resampled in April, 1985 or July 1985 due to missed holding times, anomalous results, or other QA/QC reason. See Appendix I for all laboratory reports.

4) TOC in blank of February 1984 samples; trichloroethylene in blank of November 1984 samples.

5) Pesticides & herbicides resampled in July, 1985 in Wells RFW-1, RFW-2A, RFW-3A, & RFW-4 due to excessive holding times in February, 1984 samples - No pesticides or herbicides were detected in either round.

TABLE 4-2 (cont.)

ANALYTICAL RESULTS
GROUNDWATER MONITOR WELLS

Parameter	Detection Limit and Reporting Unit	RFW-10		RFW-11	
		11/7/84	4/17/85	11/7/84	4/17/85
Phenol	0.005 mg/l	ND	-	ND	-
GC Hydrocarbon Scan	1 mg/l	ND	-	ND	-
Total Lead	0.01 mg/l	ND	-	ND	-
Detected Priority Pollutant Volatile Compounds (*)					
Toluene	<2.0 ug/l	*	2.8	*	ND
Ethyl Benzene	<2.0 ug/l	*	59	*	ND
Additional Organic Compounds (*)					
Total Xylenes	<4.0 ug/l	*	78	*	ND
Methyl Ethyl Ketone	<10.0 ug/l	*	ND	*	ND
Methyl Isobutyl Ketone	<4.0 ug/l	*	ND	*	ND

NOTES:

1) (-) - Not specified in Analytical Protocol

2) N.D. - Not found above detection limit

3) (*) - Analyses performed but resampled in April, 1985 or July 1985 due to missed holding times, anomalous results, or other QA/QC reason. See Appendix I for all laboratory reports.

4) TOC in blank of February 1984 samples; trichloroethylene in blank of November 1984 samples.

5) Pesticides & herbicides resampled in July, 1985 in Wells RFW-1, RFW-2A, RFW-3A, & RFW-4 due to excessive holding times in February, 1984 samples - No pesticides or herbicides were detected in either round.

TABLE 4-2 (cont.)

ANALYTICAL RESULTS
GROUNDWATER MONITOR WELLS

Parameter	Detection Limit & Reporting Unit	RFW-1D (2/7/84)	RFW-5D (2/8/84)	MW-B (2/8/84)	RFW-10A (11/7/84)	RFW-12 (11/7/84)	MW-12 (4/17/85)	MW-13 (4/17/85)	MW-12 (7/23/85)	MW-12A (7/23/85)
Hardness	2 mg/l	-	-	-	-	2	-		-	-
Sulfate	0.5 mg/l	-	-	-	-	N.D.	-	-	27	N.D.
Chloride	5 mg/l	-	-	-	-	1.9	-	-	8	N.D.
Nitrate-Nitrogen	0.2 mg/l	-	-	-	-	N.D.	-	-	N.D.	N.D.
Total Kjeldahl Nitrogen	0.3 mg/l	-	-	-	-	N.D.	-	-	-	-
Ammonia-Nitrogen	0.03 mg/l	-	-	-	-	N.D.	-	-	-	-
TOC	0.1 mg/l	*	*	*	-	-	1.2	1.9	-	-
TOX	5 ug/l	15.0	200.2	N.D.	-	-	-	-	-	-
Phenol	0.005 mg/l	N.D.	-	N.D.	0.006	N.D.	-	-	-	-
Oil & Grease	0.1 mg/l	2.85	1.70	0.23	-	-	-	-	-	-
IR Scan (Petroleum)	0.5 mg/l	-	-	-	-	-	-	-	-	-
GC Hydrocarbon Scan	1 mg/l	-	-	-	N.D.	-	-	-	-	-
Nickel	0.1 mg/l	N.D.	-	N.D.	-	-	-	-	-	-
Arsenic	0.1 mg/l	N.D.	-	N.D.	-	-	-	-	-	-
Chromium	0.05 mg/l	N.D.	-	N.D.	-	-	-	-	-	-
Cadmium	0.01 mg/l	N.D.	-	N.D.	-	-	-	-	-	-
Copper	0.03 mg/l	0.1	-	0.04	-	-	-	-	-	-
Cyanide	0.03 mg/l	N.D.	-	N.D.	-	-	-	-	-	-
Total Dissolved Iron	0.05 mg/l	63.3	-	N.D.	-	0.09	-	-	-	-
Total Lead	0.01 mg/l	N.D.	N.D.	N.D.	N.D.	-	-	-	-	-
Pesticides/Herbicides (4)	0.2--10 ug/l	*	*	*	-	-	-	-	N.D.	N.D.
PCB's	1 ug/l	*	*	*	-	-	-	-	N.D.	N.D.
Detected Priority Pollutant Volatile Compounds (*)		-	-	-	*	*	N.D.	N.D.	-	-
Additional Organic Compounds (*)		-	-	-	*	*	N.D.	N.D.	-	-

Notes 1 - 5 - See front page

6) See Appendix I for lab blanks, matrix spikes and other QA/QC data notes.

7) Duplicate/Original
RFW-1D/RFW-1 (2/7/84)
RFW-5D/RFW-5 (2/8/84)
RFW-10A/RFW-10 (11/7/84)
MW-12/RFW-7 (4/17/85)
MW-12/RFW-1 (7/23/85)

8) Blanks:
MW-B (2/8/84)
RFW-12 (11/7/84)
MW-13 (4/17/85)
MW-12A (7/23/85)

based on cancer risk, toxic properties, and organoleptic properties.

The limits set for cancer risk are not based on a "safe" level for carcinogens in water. The criteria state that, for maximum protection of human health, the concentration should be zero. However, where this cannot be achieved, a range of concentrations corresponding to incremental cancer risks of from one in ten million to one in one hundred thousand was presented (10^{-7} to 10^{-5}).

Toxic limits were established at levels for which no adverse effects would be produced. These are the health-related limits which have been used in this report to evaluate potential impacts. It should be noted that the cancer risk column is based on one cancer case in one million, (10^{-6}). EPA's evaluation criteria under CERCLA (Annex XIII) for selecting contaminant levels to protect public health call for a remedial action to "attain levels of contamination which represent an incremental risk of contracting cancer between 10^{-5} and 10^{-6})." The 10^{-6} value was used to represent the criterion of maximum protection to the public. These criteria are not standards nor are they issued as regulations by the EPA.

In addition to the cancer risk assessment criteria, the EPA Office of Drinking Water provides, on request, advice on health effects concerning unregulated contaminants found in drinking water supplies. This information suggests the level of a contaminant in drinking water at which adverse health effects would not be anticipated with a margin of safety; it is called a SNARL (suggested no adverse response level). Normally, values are provided for 1-day, 10-day, and longer-term exposure periods where available data exist. A SNARL does not condone the presence of a contaminant in drinking water, but rather provides useful information to assist in the setting of control priorities in cases where the contaminant has been found. SNARLS, like the cancer risk criteria, are not legally enforceable standards; they are not issued as an official regulation, and they may or may not lead ultimately to the issuance of a national standard of maximum contamination level (MCL). The latter must take into account the occurrence and relative source contribution factors in addition to health effects. It is quite conceivable that the concentration set for SNARL purposes might differ from an eventual MCL. The SNARLS may also change as additional information becomes available. In

short, SNARLS are offered as advice to assist those who are dealing with specific contamination situations to protect public health.

Because the original analytical protocol did not include analysis for specific priority pollutant volatile organic compounds (Table 3-1), a direct comparison of water quality results with EPA guidance criteria is not possible for the samples collected in February 1984.

A total organic halogen analysis was used as an initial screen to determine if evidence of the presence of chlorinated solvents did occur in groundwater samples from wells RFW-1 through RFW-7. According to Harper (1984), the EPA has concluded that "the TOX method represents a very good approximation of the true total of all chlorine, bromine, or iodine from organic compounds. As such, it provides the potential to "screen" a sample; to determine in one step whether significant quantities of halogenated organics are present. Since more than half of the EPA's Priority Pollutants are halogenated, a straightforward screening measurement is thus available."

Because upgradient wells were not installed, a comparison of upgradient and downgradient variations in TOX is not possible at present. Generalizations can be made, however, based on the levels of TOX and other analytes detected in soils and water and the follow-on supplemental second round sampling conducted at the CFTA, FFTA/NDI, and Base Landfill.

Oil and grease (O&G) and total organic carbon (TOC) were also used as screening parameters. It should be noted at the outset that unrealistic results for TOC were obtained from RFW-1 through RFW-7 from the first round of water quality sampling, performed in February 1984. Further, trichloroethylene (TCE) was present in all second round samples, including the field blank (RFW-12). It is postulated that both sets of anomalous results were caused by laboratory problems in the analysis of samples. Resampling for selected parameters was conducted in April and July 1985. The analytical results of the resampling are included on Table 4-2 and subsequent analytical tables in Section 4 of this report. The resampled analytes are noted on each table. All analytical results have been included in Appendix I. The interpretive analysis of chemical results is based on the data summarized on Table 4-2 and subsequent tables in Section 4 of this report.

4.3.1 Analytical Results - Current Fire Training Area

The analytical results for soils and groundwater from the CFTA, in conjunction with the field observations made during the test pit and drilling programs, are the basis for the following interpretations and conclusions. These findings have resulted from soil sampling and two rounds of water quality testing from RFW-5 and RFW-6 located at the CFTA.

4.3.1.1 Soil Test Results-CFTA

The 10 soil samples collected between land surface and a depth of 9 feet had varying concentrations of TOX, oil and grease (O&G) and lead. Test pits TP-10 and TP-11, which were excavated in stained areas, exhibited comparatively higher levels of these analytes (Table 4-1) within the upper 2.5 feet of the soil profile. Sample 11-1, collected between 0 and 2.5 feet in TP-11, had the highest O&G (18,200 ug/g) and lead (94 ug/g) concentrations. Sample results from test pits TP-10 and TP-11 show O&G dropping an order of magnitude or more between the shallowest and deepest samples. Trends with depth are not evident in other test pits.

Notably, the TOX results for all soil samples were very low or undetected. A TOX concentration of 0.35 ug/g was reported for soil sample 11-1 in contrast to the 18,200 ug/g O&G concentration in this sample. This suggests that chlorinated organics do not comprise a significant portion of the organic fraction detected in the soil. TOX procedures are incapable of detecting benzene, toluene, or other components of fuels such as JP-4 and Avgas which might be present at the site. Based on these soil findings, the analytical protocol for the second round of groundwater samples was developed to determine the presence of petroleum products in wells RFW-5 and RFW-6.

Lead concentrations ranged between 14 and 94 ug/g. Aubert and Pinta (1977) reported that lead is naturally present in soils at average concentrations of 15 to 25 ug/g, but that in podzols over granite or gneiss it more commonly ranges between 40 to 80 ug/g. Granitic rocks and the sands derived from them through weathering typically contain 120 ug/g of lead (Krauskopf, 1967). Based on these data, it has been estimated that levels of lead above 50 ug/g in site soils probably have resulted from past operations at the CFTA. All results, however, are within the limits of variability

reported for natural soils. Because lead at a concentration of 84 ug/g was detected at a depth of 8.5 feet in TP-12 (Table 4-1), the mobility of this analyte in groundwater was of concern and it was therefore included in the analytical protocol for the first round of groundwater analyses.

4.3.1.2 Groundwater Results - CFTA

The analytical results of groundwater samples collected from wells RFW-5 and RFW-6 are presented on Table 4-2. Field test results are included on Tables 3-6 and 3-6-1.

The results show that RFW-6 is not significantly impacted by operations at the CFTA. No lead, PC3s, or TOX compounds were detected in RFW-6, and corresponding levels of O&G were low. An IR scan for petroleum-derived hydrocarbons in this well was negative. No phenols were detected in RFW-6. Very low levels (<6 ug/L) of tetrachloroethylene and 1,2-trans dichloroethylene were detected in this well.

The first round analytical results from RFW-5 included a TOX value of 209 ug/L and an O&G concentration of 2.29 mg/L, or ten times higher than the concentrations noted in RFW-6 (Table 4-2). Consequently, the second round analytical protocol specified an extended IR Scan to differentiate petroleum fractions in the O&G. The second round sampling also included a volatile priority pollutant analysis (VOA) and phenols. At the detection levels reported (Table 4-2), no phenols or petroleum hydrocarbons were detected in RFW-5. Of the VOA compounds, tetrachloroethylene was reported in RFW-5 at a concentration of 7 ug/L. Trichloroethylene was detected at a concentration of 2.4 ug/L. Methyl ethyl ketone (MEK) was detected at 81 ug/L. Priority pollutant compounds such as benzene and toluene and other contaminants common to fire training area exercises were not detected in either of these downgradient wells. Field test results of conductivity (Table 3-6) indicate pH and conductance values consistent with a clean sand aquifer.

4.3.1.3 Contamination Profile-CFTA

The overall soil and water quality results from the CFTA show indications of minor soil and groundwater contamination. The conclusion is based on the presence of a select few priority pollutant compounds in RFW-5 and RFW-6

and the TOX (209 ug/l), and oil and grease (2.29 mg/l) concentrations in RFW-5.

Soil O&G results exhibit a wide range of concentrations. The oil and grease determination does not quantify a specific compound, but measures groups of substances on the basis of their common solubility in Freon. Therefore, the identity of the compounds contributing to the O&G determination is unknown. Soils which had elevated lead values (>50 ug/g) and contained high O&G values were stained. Visual inspection and HNu readings obtained during the test pit investigation also indicated that the soils were contaminated by the fire training activities.

The areas of residual soil contamination, as determined by both laboratory analysis and field observations, are shown in Figure 4-4. It is noteworthy that the thin zone of clayey silt and fine sand observed in certain test pits in the operational area appeared to retard and concentrate the products used in the fire training exercises. The highest levels of contamination were detected in these fine grained deposits. Of the two monitor wells, RFW-5 showed greater evidence than RFW-6 of potential contamination based on TOX.

Well RFW-5 is located within 20 feet of a buried oil tank. Residual oils were observed in this tank. Slight hydrocarbon odors (HNu: 3 to 5 ppm) were noted in TP-16 next to RFW-5 and the buried tank (Figure 4-4); however, surface soils were not stained in this area nor were stains observed in TP-16 to a depth of 6 feet. The elevated TOX and O&G results obtained from RFW-5 may be associated with leakage from this tank. However, specific analysis for priority pollutant compounds in RFW-5 indicated only very limited effects associated either with this tank or with activities at the CFTA on groundwater beneath the site. The static water level in RFW-5 is consistently less than RFW-6, suggesting a southeast component to the flow system in this area. Therefore, RFW-5 is downgradient from the principal sources of soil contamination detected in TP-10, TP-11, and TP-12. In conclusion, both RFW-5 and RFW-6 demonstrated little effects from use of this area as a fire training facility.

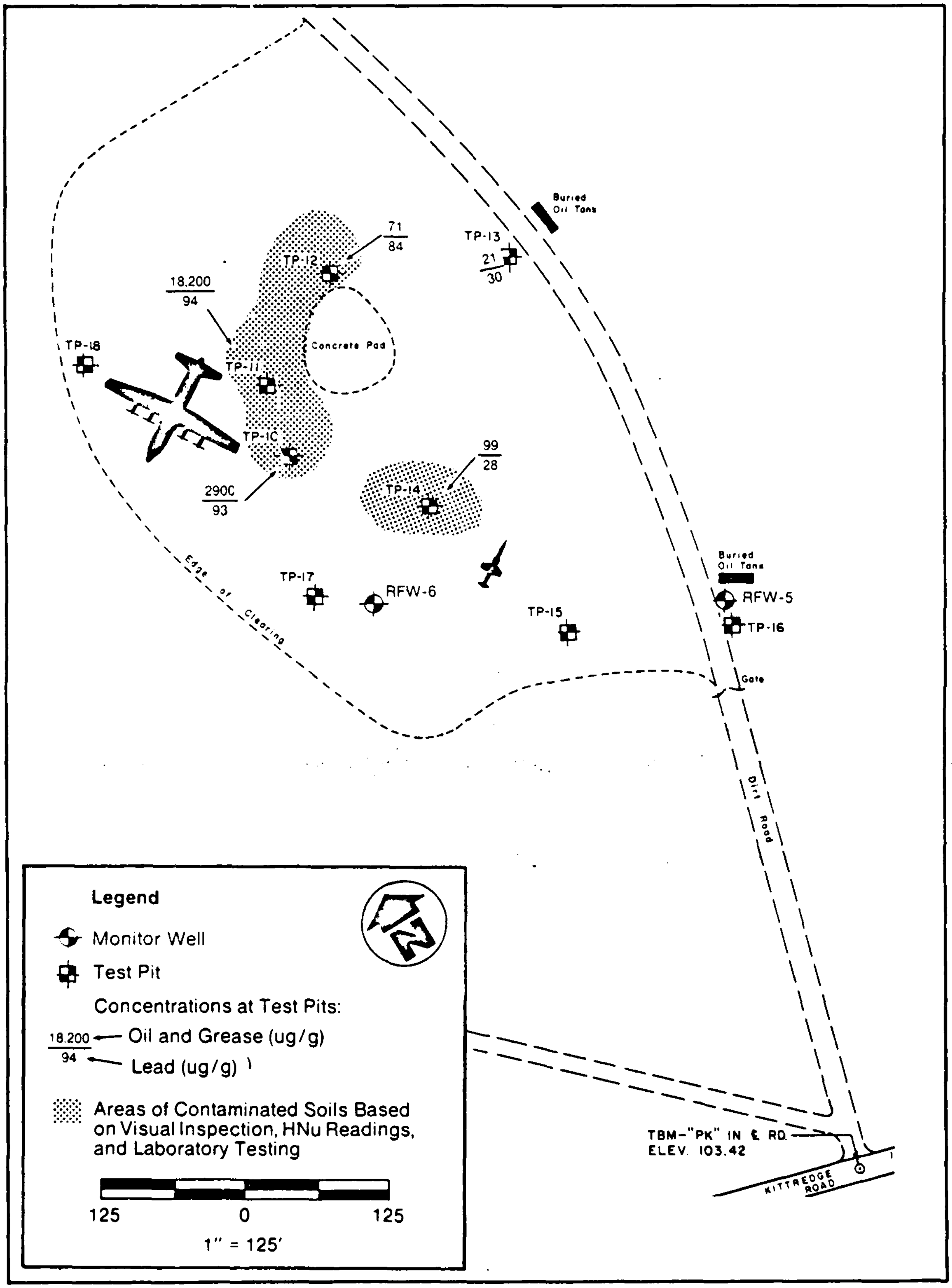


FIGURE 4-4 MAP OF CFTA SHOWING PRINCIPAL AREAS OF SOIL CONTAMINATION

4.3.2 Analytical Results - FFTA/NDI

Both soil and groundwater samples were collected from this zone. As previously described, each area was investigated with backhoe pits to identify evidence of soil contamination from prior operations. Samples of sludge and supernatant from the NDI waste sump tank were collected. A single monitor well, RFW-7, monitors the zone from a remote downgradient position.

4.3.2.1 Soil and Sump Tank Test Results-NDI

The results of soil samples from four test pits at the NDI are shown on Table 4-1. Test pits TP-21 and TP-22 are located in a runoff swale draining to the south just west of the NDI lab (Figure 4-1). Results from TP-22 represent upstream conditions in the swale; TP-21 represents downstream conditions. Although the TOX, O&G, and lead results are uniformly higher in the downstream sample, there is insufficient information to determine if the results represent a significant difference. No lithologic or environmental distinction could be made from field observations between upgradient TP-22 and downgradient TP-21. The results of the soil testing do not appear to represent evidence of significant soil contamination by the NDI in the areas observed.

Chemical results of the sludge and supernatant from the sump tank are presented in Table 4-3. These results show that the supernatant liquid in the tank contains much lower concentrations of O&G, TOX, and lead than does the sludge. The sludge O&G result of 43,800 ug/g may include the lubricants, emulsifiers, and developers used at the NDI lab. The TOX result of 43 ug/g is very low when compared to the O&G concentration. This suggests that there are no significant concentrations of chlorinated compounds in the sludge. However, the sludge does represent a potential point source of contamination and the specific parameters in the sludge, including the determination of specific priority pollutant organics, would need to be identified before disposal.

The test pit soil sampling investigation at the NDI site did not reveal any evidence of significant contamination in near surface soils below the site based on the analyses performed.

4.3.2.2 Soil Test Results-FFTA

The 11 test pits which were excavated in an attempt to pinpoint the actual locations of fire training activities at

Table 4-3

Supernatant and Sludge Analytical Results
NDI Sump Tank[1]

Sample	Oil & Grease	TOX	Lead	TOC
Supernatant Liquid	0.92 mg/l	175 ug/l	18.0 ug/l[2]	14.4 mg/l
Sludge (wet basis)	43,800 ug/l	42.9 ug/g	333 ug/g	--[3]

Notes: 1) Samples collected February 1984.

2) July, 1985 resample of lead based on excess holding time of February, 1984 sample.

3) Not specified in analytical protocol.

the FFTA defined a large burnfill deposit which was not identified in the Phase I report. This is shown in Figure 4-1 and has been discussed previously. Since no field observations clearly pointed to a fire training site (refer to Table 3-3), only two soil samples were collected in the suspect FFTA. The analytical results are shown on Table 4-1. Test pit TP-26 exhibited elevated levels of O&G and lead compared to TP-33 at the FFTA and other soil results from other sites (Table 4-1). Based on these analytical results, TP-26 is possibly in the area where former fire training exercises occurred (Figure 4-1). Because the burnfill deposits not only appeared similar but also caused similar responses on the HNu meter as soils impacted by fire training activities, no definitive finding as to the location and extent of the FFTA could be made with the data available.

4.3.2.3 Groundwater Results-FFTA/NDI

Well RFW-7 was installed to monitor the zone downgradient from the FFTA/NDI and should intercept any significant contamination migrating in the groundwater flow system. The results of chemical analyses from two rounds of sampling are presented in Table 4-2. No evidence of TOX, lead or PCBs were detected in the February 1984 analysis. Because the O&G result from the first round of sampling was 2.09 mg/L, an extended IR Scan for hydrocarbons and analyses for phenols and for volatile organic priority pollutants were performed in the November 1984 second-round sampling. The second round results including resampling for volatile priority pollutant compounds in April 1985 showed no detectable evidence of contamination.

4.3.2.4 Contamination Profile-FFTA/NDI

Significant soil or groundwater contamination at the FFTA/NDI was not found. The sludge in the NDI sump is a potential contamination source that is worth consideration for characterization and potential remedial action in light of the analytical results. A more complete analysis would need to be performed on the sludge to determine if it would be characterized as a hazardous waste.

The old burnfill deposits which were encountered in the areas depicted on Figure 4-1 do not represent a hazardous environmental condition based on the water quality results from RFW-7. The burnfill deposits generally were covered with 1 to 2 feet of clean fill and were not exposed at the

surface. Therefore, direct contact with this material is improbable. Because the material was burned, volatile compounds are not predicted to be present in these deposits in appreciable quantities. The TOX results of soil samples collected from the FFTA were either very low or undetected.

4.3.3 Analytical Results - Base Landfill

The test pit investigation conducted in November 1983 was aimed at defining the approximate lateral extent of fill deposits at the site. Figure 4-2 depicts the approximate lateral extent of fill debris. No soil samples were collected for analysis during the test pit investigation.

4.3.3.1 Groundwater Results-Base Landfill

A total of four monitor wells were installed in the anticipated downgradient groundwater flow direction. Due to problems with bent casings in RFW-2 and RFW-3, wells RFW-2A and RFW-3A had to be installed as replacement wells. The analytical results of two rounds of sampling and resampling are presented in Table 4-2.

Minor impacts attributable to landfilling operations are inferred from the groundwater analytical results. These are most noticeable in RFW-1 where iron, TKN, ammonia nitrogen, and the IR Scan results for petroleum products are comparatively higher than in the other wells downgradient of the Base Landfill. Landfilling impacts in RFW-1 are also evident in the field test results presented in Table 3-6-1. RFW-1 exhibits about two to three times higher levels of specific conductance than wells RFW-2A through RFW-4, which are representative of the natural background values for specific conductance (Table 3-6-1). During development and sampling of RFW-1, the water appeared to be high in iron and the pumpage exhibited a slightly septic odor. Therefore, it has been concluded that landfill operations have had some impact on RFW-1. Three priority pollutants volatile organic compounds were detected in the April 1985 resampling of RFW-1. The concentrations ranged from 6.4 to 22 ug/L. Methyl isobutyl ketone (5.3 ug/l) was also identifed just above the detection limit of 4.0 ug/l. No pesticides, PCB's, cyanide, or significant levels of priority pollutant metals were detected in RFW-1.

Volatile priority pollutant compounds were also detected in samples from wells RFW-2A, RFW-3A and RFW-4 (Table 4-2).

RFW-2A exhibited the presence of five priority pollutant compounds ranging in concentration from 3.5 ug/L (tetrachloroethylene) to 18 ug/L (trichloroethylene). The sample from well RFW-3A showed the presence of two priority pollutant compounds with individual concentrations less than 7 ug/L. The sample from RFW-4 had five priority pollutant compounds identified in concentrations ranging from 2.8 ug/L (carbon tetrachloride) to 9.0 ug/L (1,1,1-trichloroethane). The results showed the presence of various priority pollutant compounds in low concentrations (<25 ug/L) in all Base Landfill wells. It is important to note that methylene chloride was detected in the trip blank (Appendix I, page I-20) at a concentration of 5.6 ug/L. Methylene chloride was also detected in wells RFW-2A, RFW-3A, and RFW-4 at concentrations ranging between 2.0 and 6.5 ug/L. Therefore, it is concluded that the presence of methylene chloride in these samples is not representative of actual groundwater quality. No organic analytes appeared consistently in all of the well samples. No other significant indications of landfill-derived leachate were present in these downgradient wells, based on the analyses performed.

4.3.3.2 Contamination Profile-Base Landfill

The four wells installed downgradient of the Base Landfill exhibit minor evidence of landfill-derived leachate based on the presence of volatile organic compounds. The results indicate the potential for a southwesterly component to the flow system based on the presence of analytes typical of landfill-derived leachate in RFW-1. Evidence for landfill leachate in well RFW-1 includes elevated levels of iron, sulfate, TKN, ammonia nitrogen, specific conductance, and an IR Scan indicating the presence of petroleum based product. Concentrations of these analytes in groundwater above background are indicative of typical landfill-derived leachate. The evidence of slight contamination in RFW-2A, RFW-3A and RFW-4 includes relatively low levels of TOX, O&G, and volatile organic compounds.

It is not known whether RFW-1 is representative of the most concentrated portion of the groundwater outflow from the Base Landfill. Hydraulic gradients in the area are very low, and further definition of the groundwater flow gradients in this area might be useful in improving the understanding of the site hydrogeology.

4.3.4 Analytical Results - Avgas Fuel Test Dump Site

Chemical testing of the soils and groundwater in the vicinity of the AFTDS was undertaken to determine the presence or absence of contamination resulting from past site use. The analytical results of sampling are presented in Tables 4-1-1 (soils) and 4-2 (groundwater). These results and the observa-

tions made during the exploratory test pit and drilling efforts are the basis for the following findings.

4.3.4.1 Soil Test Results-AFTDS

Four soil samples were collected from suspect discolored soils in test pits TP-3A, TP-6A, TP-7A, and TP-8A and analyzed for the presence of lead, phenols and fuel hydrocarbons. Fuel hydrocarbons were analyzed by flame ionization detection techniques using a gas chromatograph (FID-GC). Fuels were not detected in any of the tested soils. During the exploratory test pit investigation, no increases in HNu readings were recorded above background conditions. With the exception of a lead concentration of 532 ug/g in TP-7A, all lead and phenol results appeared to be within anticipated background concentrations. The lead result in TP-7A is an order of magnitude higher than anticipated background concentrations (<50 ug/g). However, all test pits surrounding TP-7A exhibited background levels of lead (24-27 ug/g). Therefore, migration of lead through the soils is not indicated by the test results. Based on the above findings, significant soil contamination at the AFTDS was not detected.

4.3.4.2 Groundwater Results-AFTDS

Monitor well RFW-11 was installed downgradient of the site to detect evidence of former fuel dumping activities. The analytical results for this well are presented in Table 4-2. As shown, no phenols, fuels (IR Scan), lead, or volatile priority pollutant compounds were detected. During the course of well drilling, soil samples were screened with an HNu meter. Slight needle deflections were noted from split spoon soil samples S-3 and S-4 (Log of RFW-11, Appendix D) at 20 and 30 feet below land surface. However, no fuel odors were noted.

4.3.4.3 Contamination Profile-AFTDS

Based on the soil and groundwater investigations conducted at the AFTDS, no significant residual contamination from this suspect site was detected. The original Phase I investigation reported that 50,000 or more gallons of fuel may have been dumped at this site during a 15-year period between 1955 and 1970 (Table 1-3). Therefore, some residual contamination in this area was anticipated.

Fuel evaporation upon dumping, the retentive capacity of soil above the water table (average depth 45 feet), and the highly permeable nature of the underlying outwash deposits may account for the absence of detectable levels of fuel at this site. Calculations of the volumetric flow rate through the aquifer (Subsection 4.2.2) indicates that the dilution capacity of the aquifer has a very great potential for mitigating the effects of contamination from the site.

But even with this dilution factor and subsequent groundwater flow beneath the site since the last discharge in 1970, the presence of hydrocarbons should be detectable in soils or groundwater if the assumed volume of product discharge to the groundwater is accurate. The absence of measureable levels of hydrocarbon in soils and groundwater at the AFTDS suggests that significantly less than 50,000 gallons of product was actually discharged.

4.3.5 Analytical Results - Railyard Fuel Pumping Station

Chemical testing of soils and groundwater at the former RFPS was conducted to determine the presence or absence of contamination resulting from past site use. The results of soil and groundwater sampling are presented in Tables 4-1-1 and 4-2, respectively. In addition, two header pipes at the loading racks of the rail line were sampled because liquids had been observed in these pipes at the time of the Phase II Presurvey Investigation. These results and the field observations made during the test pit and exploratory drilling investigations are the basis for the following findings.

4.3.5.1 Soil Test Results-RFPS

Four samples of discolored soils were collected at test pits TP-1, TP-9, TP-14, and TP-16 (Figure 3-6). Because the products which might have been spilled at this site were JP-4 and Avgas, a FID-GC scan for hydrocarbons and analyses for phenols and lead were requested. Following the discovery of waste liquid in several of the header pipes, additional priority pollutant volatile organic analyses of soil samples was recommended.

The results reported in Table 4-1-1 indicate low concentrations of phenols and lead in soils from Test Pits TP-1, TP-9, TP-14 and TP-16. The FID-GC analysis did not detect the presence of any hydrocarbons at the 1 ug/g level. Based on these results and the lack of a detectable presence of

organic vapors measured by the HNu, it is concluded that there is no significant residual fuel contamination in the near surface soils down to a depth of 10 feet in and around the RFPS.

Volatile organic analyses of soils were performed on the four soil samples collected at the RFPS. The results are reported in ug/kg or parts per billion (Table 4-1-1). Methylene chloride was detected in TP-9 and TP-16 at 1100 and 810 ug/kg respectively. It should be noted that methylene chloride was detected in all of the soil samples, but not in a laboratory blank. The results are higher than would be expected from laboratory-induced contamination. At this time, the source of the methylene chloride is unknown. The results are not significant in terms of adverse environmental impacts to ground or surface waters. This is discussed further in the following section of this report.

The acetone result of 52 ug/kg in TP-14 may be the result of laboratory contamination. This is a common occurrence at the detection level noted. However, it was detected in only two of the four samples and was not detected in the laboratory blank. Therefore, it is concluded that the results are representative of actual soil conditions. Overall, the results of the volatile organic analysis of soils at the RFPS did not indicate the presence of significant concentrations of residual contamination. Those contaminants which were detected may have been associated with cleaning operations at the RFPS but they are not normal components of the fuels which were pumped from there.

4.3.5.2 Pipe Sampling Results-RFPS

Two header pipes at the RFPS were sampled on 13 December 1984. Sample S-1 was collected from header 12; S-2 was collected from header No. 7. Resampling for acid and base/neutral compounds (ABN) was performed on 23 July 1985 since recommended holding times in the initial samples were exceeded. Results are presented in Table 4-4. In addition, a comparative analysis (GC/FID) of the materials in the header pipes was made with Mogas, Avgas, JP-4, heating oil, and diesel fuel. Both samples were reported to be similar to JP-4. Sample S-1 from header 12 appeared to be diluted; S-2 was totally miscible in hexane. Both were concluded to be weathered fuel products; however, the December 1984 S-2 sample was concentrated, whereas S-1 was dilute.

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Table 4-4

ANALYTICAL RESULTS OF HEADER PIPE
AND WASTE OIL SAMPLES
RAILYARD FUEL PUMPING STATION (1)

Sample Number	S-1 (Header 12)	S-2 (Header 7)
GC/FID Capillary Column	Similar to 0050 (JP-4) (diluted)	Similar to 0050 (JP-4) Completely miscible in Hexane (concentrated)
Lead	29 mg/l	0.037 mg/l

DETECTED COMPOUND OF ACID BASE/NEUTRAL ANALYSES
OF SAMPLES COLLECTED JULY 1985 (2)

	Header 12	Header 7
Napthalene	750 mg/l	1,200 mg/l
Ethyl Benzene	>20,000 mg/l	
Toluene	>12,000 mg/l	
Total Xylenes	>43,000 mg/l	

Notes:

1) GC/FID and lead samples collected December 1984. December 1984 samples for acid and base/neutral analyses exceeding recommended holding times. Resampled July 1985.

2) Qualitative/Semi-Quantitative report of elevated presence of ethyl benzene, toluene, and total xylenes in Header 12 using Method 625. Napthalene only base neutral compound detected.

The July 1985 results of the ABN analyses revealed the presence of napthalene in both headers. EPA Method 625 detected the presence of toluene, ethyl benzene and total xylenes in header 12 at levels of approximately 1 to 4 percent. These compounds were not part of the EPA 625 protocol but were detected. Because they were outside of the calibration range of the primary target compounds, they were semi-quantified. The GC/FID analysis performed on the December 1984 samples and the later capillary column GC/MS analysis both reveal qualitative profiles of these substances representative of a weathered fuel product.

4.3.5.3 Groundwater Results-RFPS

Wells RFW-8 and RFW-9 were installed to monitor water quality and flow conditions downgradient from the RFPS. The wells monitor the upper portion of the zone of saturation (20 feet) at this site. Test results from samples collected in November 1984 and resampling in April 1985 are presented in Table 4-2. Since spilled fuel was the chief potential contaminant of concern, the well water was examined for fuel content, phenols, lead, and volatile organics including benzene and toluene. Low concentrations of ethyl benzene (2.8 ug/L) and total xylenes (4.6 ug/L) were detected in RFW-9. These may be associated with fuel spillage from the RFPS. The elevated methyl isobutyl ketone result (210 ug/L) is not normally a suspect organic compound where fuels are concerned. Its presence or actual source is unknown since it was not detected in the test pit results. Methylene chloride or acetone which were detected in soils from TP-9, TP-14, and TP-16 were not detected in groundwater from wells RFW-8 and RFW-9. Significantly, neither the hydrocarbons which were detected in the header pipes nor the volatile organic components in the soil were detected in monitor wells RFW-8 and RFW-9.

4.3.5.4 Contamination Profile-RFPS

The RFPS had been used at least between the years 1959 and 1965 for off-loading of JP-4 and Avgas product. Table 1-3 suggests that spills of 10,000 gallons or more may have occurred during this period.

The lack of significant evidence of residual on-site contamination indicates that the site at present is not causing adverse impacts on ground or surface waters. Wells RFW-8 and RFW-9 are located between 500 and 1,000 feet from the site. Based on an estimated groundwater linear velocity of one to two feet per day, these wells are within the area potentially affected by a continuing source of pollution from this site if it exists. Because the disposition of

weathered product in the header pipes, and possibly the transmission lines, has not been determined, recommendations for undertaking closure actions are made in Section 6 of this report.

4.3.6 Analytical Results - Petrol Fuel Storage Area

The Petrol Fuel Storage Area is an unranked site which currently is used for the storage of JP-4 and heating oil. Historically, there have been no specific reports of large product losses. However, because the site contains large quantities of petrol product (42,500 barrels), a single remote downgradient well was installed to detect any petrol contaminants which might occur in the upper portion of the zone of saturation.

The analytical results of a single groundwater sample from Well RFW-10 are presented in Table 4-2. Toluene, ethyl benzene and xylene were detected; the maximum concentration found was 78 ug/L total xylenes. Although a GC/FID hydrocarbon scan did not detect the presence of hydrocarbons at the 1 mg/L level, this result is inconsistent with field observations made since petrol/fuel odors were noted during the drilling of the well. An HNu reading of 12 ppm above background was monitored in a water sample extracted from the well during drilling. A small amount of fuel was also observed on the water level probe line at the time that water level measurements were taken.

When this well was sampled, a submersible pump was used to purge the well. The pump was set approximately 10 feet below the water level and allowed to run until three volumes of the well had been evacuated. A sample was then collected from the well by immersing a 4-foot long teflon bailer completely into the zone of saturation. It is concluded that this sampling technique was representative for the water column as a whole, but did not accurately sample oils or fuels which may have been present floating on the water surface within the well.

4.3.6.1 Contamination Profile-PFSA

Based on the above results, some groundwater contamination attributable to operations at the PFSA is evident. The magnitude of the contamination is unknown. The results of the sampling at RFW-10 do not appear to represent a large volume

of product from the site; however, additional actions are recommended to evaluate this condition further.

4.4 CONCLUSIONS

The conclusions outlined in this section are based on an analysis of the geologic and hydrogeologic conditions encountered at Otis ANGB, as well as analytical results from soil samples (Tables 4-1 and 4-1-1), field tests (Tables 3-6 and 3-6-1), a single round of groundwater sampling conducted at RFW-8 through RFW-11, two rounds of sampling conducted at RFW-1 through RFW-7 and resampling for selected analytes which exceeded holding times or were highly suspect (Table 4-2).

1. The geologic setting at Otis ANGB consists of 200 to 300 feet of medium to coarse sands and gravels of glacial outwash origin. The sands reportedly become finer with depth (below 200 feet). The sands unconformably overlie crystalline basement rocks at depths exceeding 250 feet.

2. Groundwater occurs under unconfined or water table conditions in highly permeable, homogeneous sands and gravels underlying all sites investigated in this study. Groundwater flow in these deposits occurs generally in a southerly direction although there is a mild groundwater divide crossing the Base so that flow diverges either to the southwest or the southeast. This conclusion is based on the water level measurements taken in the monitor wells completed for this study. Hydraulic conductivities of 200 to 300 feet per day have been estimated by others (LeBlanc 1982). These estimates seem reasonable in light of the soil and sediment conditions encountered during this investigation (see Boring Logs, Appendix D) and the indications of high permeability yielded by the in situ permeability testing conducted on the monitor wells during development.

3. Groundwater flows under a relatively low hydraulic gradient of between 0.001 and 0.002. Due primarily to the high permeability of the underlying sands and gravels, average linear velocities on the order of 1 to 2 feet per day have been calculated. This indicates that

constituents in the groundwater may migrate on the order of 300 to 700 feet per year.

4. Groundwater generally occurs between 40 and 80 feet below land surface at Otis ANGB. The depth to the regional water table increases to the northwest and was found to be deepest in the vicinity of the Base Landfill. Otis ANGB comprises a portion of the groundwater recharge zone for the Falmouth area south of the Base.

   Due to the great depth to the water table, perennial surface streams do not occur at Otis ANGB. Any runoff swales or seasonal surface water flows at Otis ANGB are influent; that is, they discharge to the deeper groundwater flow system. Several deep ponds or kettle holes on or near the Base (Figures 2-4 and 4-3) are hydraulically connected to the regional aquifer and reflect the surface of the regional water table.

5. From the above findings, it is concluded that the groundwater flow system underlying Otis ANGB constitutes a valuable, high-yielding aquifer. By virtue of the sandy overlying deposits, it is susceptible to contamination not only from point sources at land surface but also from nonpoint disharges through influent streams. It is also concluded that a certain buffering capacity exists to mitigate potential contamination from surface activities. One factor affecting the mitigating potential is the thickness of the vadose zone (unsaturated zone above the water table) which can exhibit retentive or attenuative properties for certain potential contaminants including hydrocarbons. A second factor is the productivity of the aquifer, resulting in significant dilution capacity to reduce the impact of potential contaminants generated by surface activities and migrating through the vadose zone to the water table.

6. Table 4-5 presents water quality criteria standards and guidance criteria for various analytes of concern which were selectively monitored in wells RFW-1 through RFW-11. From this table, it is evident that

Table 4-5

COMPARISON OF WATER QUALITY CONSTITUENTS
WITH WATER QUALITY GUIDANCE CRITERIA AND STANDARDS

Parameter (mg/l unles noted)	Reporting Detection Limit	Unit	(A) Massachusetts & Federal Standard	(B) Quality Criteria for Water (Domestic)	(C) Water Quality Criteria Documents	(D) SNARLS	Wells Exceeding the Limits
Cyanide	0.03	mg/l	--	0.05	0.2	--	None
Phenol	0.005	mg/l	--	0.001	3.5	--	RFW-1 (B), RFW-10 Dup (B)
PCB	1.0	ug/l	--	--	0.79	0.3	None
Iron	0.05	mg/l	0.3	0.3	--	--	RFW-1 (A)
Copper	0.03	mg/l	1.0	1.0	1.0	--	None
Cadmium	0.01	mg/l	0.01	0.01	0.006 ug/l	--	None
Chromium	0.05	mg/l	0.05	0.05	0.05	--	None
Lead	0.01	mg/l	0.05	0.05	0.05	--	None
Arsenic	0.01	mg/l	0.05	0.05	0.2 ng/l	--	None
Nickel	0.1	mg/l	--	--	0.0134	--	None
Endrin	0.0004	mg/l	0.0002	0.0002	--	--	None
Lindane	0.00028	mg/l	0.004	0.004	--	--	None
Methoxychlor	0.0013	mg/l	0.1	0.1	--	--	None
Toxaphene	0.0048	mg/l	0.005	0.005	--	--	None
2,4-D	0.06	ug/l	0.1	--	--	--	None
2,4,5-TP (Silvex)	0.02	ug/l	0.01	--	--	--	None
Oil & Grease	0.1	mg/l	--	0.0	--	--	(1)
pH	0.12	s.u.	6.5 - 8.5	5.09 - 9.0	--	--	(2)
Trichloroethylene	2.0	ug/l	--	--	2.7	75.	RFW-2A (C)
Trichlorofluoromethane	3.0	ug/l	--	--	0.19	--	RFW-4 (C)
1,1,1-trichloroethane	2.0	ug/l	--	--	18,400.	1,000.	None
Tetrachloroethylene	2.0	ug/l	--	--	0.8	40.	RFW-2A (C), RFW-5 (C), RFW-6 (C)
Ethyl Benzene	2.0	ug/l	--	--	1,400.	--	None
Xylene	4.0	ug/l	--	--	--	620.	None
Dichlorobenzene	3.0	ug/l	--	--	400.	--	None
Carbon Tetrachloride	2.0	ug/l	--	--	0.40	--	RFW-4 (C)

(1) Method detection limit exeeeded Water Quality Criteria Limit.
(2) Naturally occurring acidic water with no buffer capacity.

groundwater sampled in the monitor wells generally meets both regulated standards and guidance criteria for water quality.

7. No evidence of groundwater pollution suggesting significant adverse health effects was noted in any of the monitor wells. Wells RFW-1, RFW-2A, and RFW-4, at the Base Landfill, RFW-5 (CFTA) and RFW-10 (PFSA) were concluded to be slightly impacted by former or present operations or disposal activities. Monitor wells RFW-2A, RFW-5, and RFW-6 contained tetrachlorethylene at levels above the 0.8 ug/L guidance criterion; however, these wells were well within the 40 ug/L lifetime SNARL (Section 4.3). A sample from well RFW-4 contained carbon tetrachloride (2.8 ug/L) which is above the 0.4 ug/L guidance criterion for a 10^{-6} cancer risk.

8. With the exception of copper, which was well within Federal Drinking Water Standards, priority pollutant metals were not detected in any of the landfill monitor wells, nor were cyanide, pesticides or PCB's. This indicates that the Base Landfill is not posing a significant threat to water resources based on these priority pollutant compounds.

9. The Current and Former Fire Training Areas, the Avgas Fuel Test Dump Site and the Railyard Fuel Pumping Station, are not adversely impacting area water resources based upon the monitoring performed. Well RFW-9 exhibited 210 ug/L of methyl isobutyl ketone. There are no guidance criteria indicating significant adverse impacts from this concentration. Significant impacts would have been detected by IR Scans, GC/FID hydrocarbon scans, or the volatile organic analyses performed on groundwater samples from these wells. RFW-7, which also serves as a remote monitor well for the NDI lab, did not reveal evidence of contamination from that former facility either.

10. The sump tank at the NDI lab contains sludges which have not been classified as to their hazard. Although downgradient monitoring has not detected

adverse environmental impacts from this facility, the contents of the sump tank warrant determination.

11. RFW-10, which is located downgradient of the Petrol Fuel Storage Area, exhibited xylenes and ethyl benzene within health-related guidance criteria for drinking water. Further, fuel odors (12 ppm above background) detectable on the HNu were measured in a soil/water sample collected during the drilling of well RFW-10. Although the contaminant levels noted in RFW-10 do not represent an imminent adverse health threat, their presence warrants further investigation at and beyond the potential source of contamination.

SECTION 5

ALTERNATIVE MEASURES

The principal goal of the Phase II, Stage 1 Problem Confirmation Study at Otis ANGB was to determine whether or not environmental degradation has occurred as a result of past activities at seven sites identified in the Phase I Presurvey Studies. The conditions presented in Section 4 indicate that, to date, the impact of historic and on-going activities on groundwater quality has been minimal. The alternative actions at Otis ANGB to be considered can be categorized as follows:

1. Preparation of an on-site well inventory.

2. Preparation of Closure Plans for the NDI sump tank and the subsurface tanks at the CFTA, and for the header pipes and the transmission line at the RFPS.

3. Expansion of the water quality monitoring network at the CFTA, Base Landfill and PFSA sites.

The following describes the outlined alternative actions in more detail.

5.1 PREPARATION OF ON-SITE WELL INVENTORY

Additional production and monitor wells exist at Otis ANGB. These were installed by others prior to or during the Phase II investigation. These wells could provide supplementary information regarding water quality conditions in and around the identified facilities. For example, several monitor wells originally drilled for an experimental wastewater spray irrigation project are located downgradient of the CFTA. One of these wells reportedly exhibits an oily odor (Phase II, Presurvey Report). Inventorying these wells and, if appropriate, monitoring a selected number on an interim basis could assist in further assessments of water quality conditions related specifically to the CFTA, Base Landfill and PFSA.

5.2 PREPARATION OF CLOSURE PLANS FOR THE NDI SUMP TANK, THE BURIED TANKS AT CFTA, AND THE HEADER PIPES AND TRANSMISSION LINES AT THE RFPS

Disposition of the sludge in the NDI sump tank needs to be considered. Additional sampling of the sludge, however, would need to be conducted prior to locating an approved disposal facility. The quantity of sludge in the NDI sump tank must be estimated to provide a cost basis for further actions. The buried tanks at the CFTA should be sampled for product content and plans made for their removal or backfill.

Recommendations with alternatives, including the no action alternative, should be addressed in a brief feasibility analysis for both the NDI sump tank and the tanks at the CFTA.

The header pipes and transmission line at the RFPS contain evidence of weathered fuel product, considered a hazardous substance. The quantity of weathered product remaining in the line is unknown. The potential for groundwater degradation from the residual petroleum product as long as it is present in the lines, is remote. A plan of action or Closure Plan could be developed to address final closure of these facilities. This would involve preparing a decision matrix on which a closure course of action might be based. For example, pumping and flushing the lines would be one option; end-plugging all openings and continued periodic monitoring would be another. These and other possibilities would be addressed in the Closure Plan. In the meantime, annual monitoring for volatile organic compounds including xylenes, MEK, and MIBK is recommended for all monitoring wells where closure actions are to be undertaken. In addition, monitoring for the presence of fuel hydrocarbons should be performed at the CFTA and RFPS.

5.3 EXPANSION OF THE WATER QUALITY MONITORING NETWORK

The Current Fire Training Area (CFTA), Base Landfill, and Petrol Fuel Storage Area have the potential for contributing to groundwater contamination. The Phase II monitor wells at these sites provide water quality information sufficient and pertinent to a confirmation stage investigation. They do not necessarily provide comprehensive site monitoring.

Typically, a comprehensive groundwater monitoring system includes an upgradient well and wells located in each dominant

downgradient direction. A minimum of four wells is usually desirable for water quality monitoring and accurate flow information. On large sites, additional wells are needed to improve the quality of site assessment. Based on the analytical results, expanded monitoring at the CFTA, Base Landfill and RFPS is warranted. This should include annual monitoring for volatile organics and the presence of fuel hydrocarbons.

5.3.1 Current Fire Training Area

A comprehensive monitoring system at the CFTA would include additional wells in close proximity to the CFTA. The wells would augment RFW-5 and RFW-6 and provide upgradient flow and water quality information.

5.3.2 Base Landfill

The Base Landfill does not have an upgradient monitoring well. In addition, a southwesterly component to the flow system identified in this investigation (Figure 4-3) and analytical results for RFW-1 indicate the need for downgradient monitor wells which would provide a more comprehensive monitoring system for this facility.

5.3.3 Petrol Fuel Storage Area

The PFSA is monitored by RFW-10. RFW-10 showed indications of contamination in one sample from that well. This condition could be further explored through an expanded monitoring program, including both groundwater and off-site surface water bodies, in order to verify the severity of potential contamination from the PFSA. The additional monitoring of the site would improve the assurance that the storage facility is not significantly impacting water resources.

5.4 SUMMARY

Significant adverse environmental impacts arising from past hazardous waste-related operations at Otis ANGB have not been detected in the Phase II Confirmation Study. Phase II observations of low-level impacts at the CFTA, the Base Landfill, and the PFSA warrant additional monitoring. Closure disposition actions should be taken at the NDI sump tank, the buried tanks at the CFTA, and the RFPS header pipes and transmission lines. The Former Fire Training Area/Non-Destructive Inspection Laboratory and the Avgas Fuel Test Dump Site do not require additional monitoring based upon the study results.

SECTION 6

RECOMMENDATIONS

The findings of the Phase II, Stage 1 Problem Confirmation Study at seven sites, including one unranked site (PFSA), at Otis ANGB indicate that groundwater quality downgradient from the sites investigated has not been significantly impacted by past activities. The Former Fire Training Area/Non-Destructive Inspection Laboratory and the Avgas Fuel Test Dump Site do not require additional evaluation because results of this study indicate they have not contributed to groundwater contamination. However, some evidence of potential contamination from the other sites has been collected in this study. Follow-up IRP activities are recommended at these sites. In addition, it is recommended that closure actions by instituted at three sites where bulk storage of potentially hazardous wastes exists. Thus, the recommendations resulting from this study can be divided into three categories:

1. Preparation of an on-site well inventory.

2. Closure actions at the CFTA buried tanks, the NDI sump tank, and the RFPS header pipes and transmission lines.

3. Expansion of the water quality monitoring network at the CFTA, Base Landfill, and PFSA.

6.1 On-Site Well Inventory

A well inventory of all wells on the Base is recommended. The well inventory should identify the wells by location, type, use, yield, present status for monitoring, construction details, geologic information, water quality analysis, or other pertinent information. The well inventory will serve as a basis for site assessment evaluations as necessary from the work performed to date. The well inventory will provide a ready access of known groundwater monitor points on Otis ANGB.

6.2 CLOSURE ACTIONS

Closure actions are recommended for the two buried tanks at the CFTA, the NDI sump tank, and the RFPS header pipes and transmission lines. Although no significant groundwater contamination or environmental degradation has been detected at any of these former facilities, the presence of potentially

hazardous wastes under unsecured conditions poses a potential future threat to the environment.

6.2.1 Closure Analysis - CFTA Waste Oil Tanks

Observations indicate that only one of the two buried tanks at the CFTA has residual oil remaining in it. This oil should be sampled, tested for hazardous waste characteristics (ignitability and corrosivity), and analyzed for VOA, acid and base/neutral extractables, priority pollutant metals, and PCB. Results should be used as the basis for selection and evaluation of potential closure action, such as tank removal. While this work is in progress, the existing wells should be monitored on an annual basis for the presence of volatile organic compounds and fuel hydrocarbons.

6.2.2 Closure Analysis - NDI Sump Tank

The sludge at the NDI sump tank should be resampled for hazardous waste characteristics, including laboratory analyses for ignitability, corrosivity, PCB, priority pollutant metals, volatile organics, and acid and base/neutral extractables. Following these analyses, the alternatives for disposal on- or off-site should be evaluated. Potential alternatives to be considered include removal of the sump tank contents and plugging of the sump tank drain, or tank removal. Remote well RFW-7 should be monitored for volatile organic compounds on an annual basis while this work is in progress.

6.2.3 Closure Plan of Action - RFPS

A closure plan of action, including development and evaluation of potential alternatives, should be prepared for effecting an approved closure action at the RFPS facilities. Since minor contamination was detected in RFW-9 at the RFPS, plugging of heads and transmission pipes, and periodic monitoring of the perimeter monitor wells is a possible course of action. However, if it is practical to retrieve weathered residual product from these lines, this alternative should also be evaluated. Annual monitoring for volatile organic compounds, total xylenes, MEK, MIBK and fuel hydrocarbons is recommended until final disposition of the site has been determined.

6.3 EXPANSION OF WATER QUALITY MONITORING NETWORK

The CFTA, Base Landfill, and PFSA are active sites where an expanded monitoring program is needed. The rationales for expanded monitoring have been reviewed in Section 5. Recommended supplemental well locations at each site are shown in Figures 6-1 through 6-3.

6.3.1 CFTA Supplementary Wells

Two additional wells are proposed at the locations shown in Figure 6-1. These wells will provide more comprehensive coverage of the site in terms of water quality and local flow information. The wells should be drilled approximately 20 feet into the seasonal low water table and be screened a short distance above the water table to detect the presence, if any, of floating hydrocarbons.

6.3.2 Base Landfill Supplementary Wells

Three additional wells should be drilled at the locations shown on Figure 6-2. A well north of RFW-1 is needed to monitor flow from the northern portions of the landfill to the west. An upgradient well is needed to improve groundwater flow information and provide background water quality data. A remote downgradient well is recommended between the Base Landfill and Otis ANGB supply well G to determine potential migration of contaminants, if any, from the area of the Base Landfill toward the Base supply well. The wells should be screened in the upper 50 feet of saturated deposits.

6.3.3 PFSA Supplementary Wells and Surface Water Stations

Three additional monitor wells are recommended for the PFSA to define the presence of a floating hydrocarbon layer at the active facility. The wells should be constructed to penetrate the upper 20 feet of the zone of saturation and be screened above the seasonal high water table to detect floating hydrocarbons, if present. Surface waters in ponds south of the PFSA should also be sampled for the presence of hydrocarbons. Up to six surface water sampling locations are recommended. If there are any existing private wells off-Base in the vicinity of the Cranberry Bog south of the PFSA (Figure 6-3), they should be inventoried for potential use as sampling points.

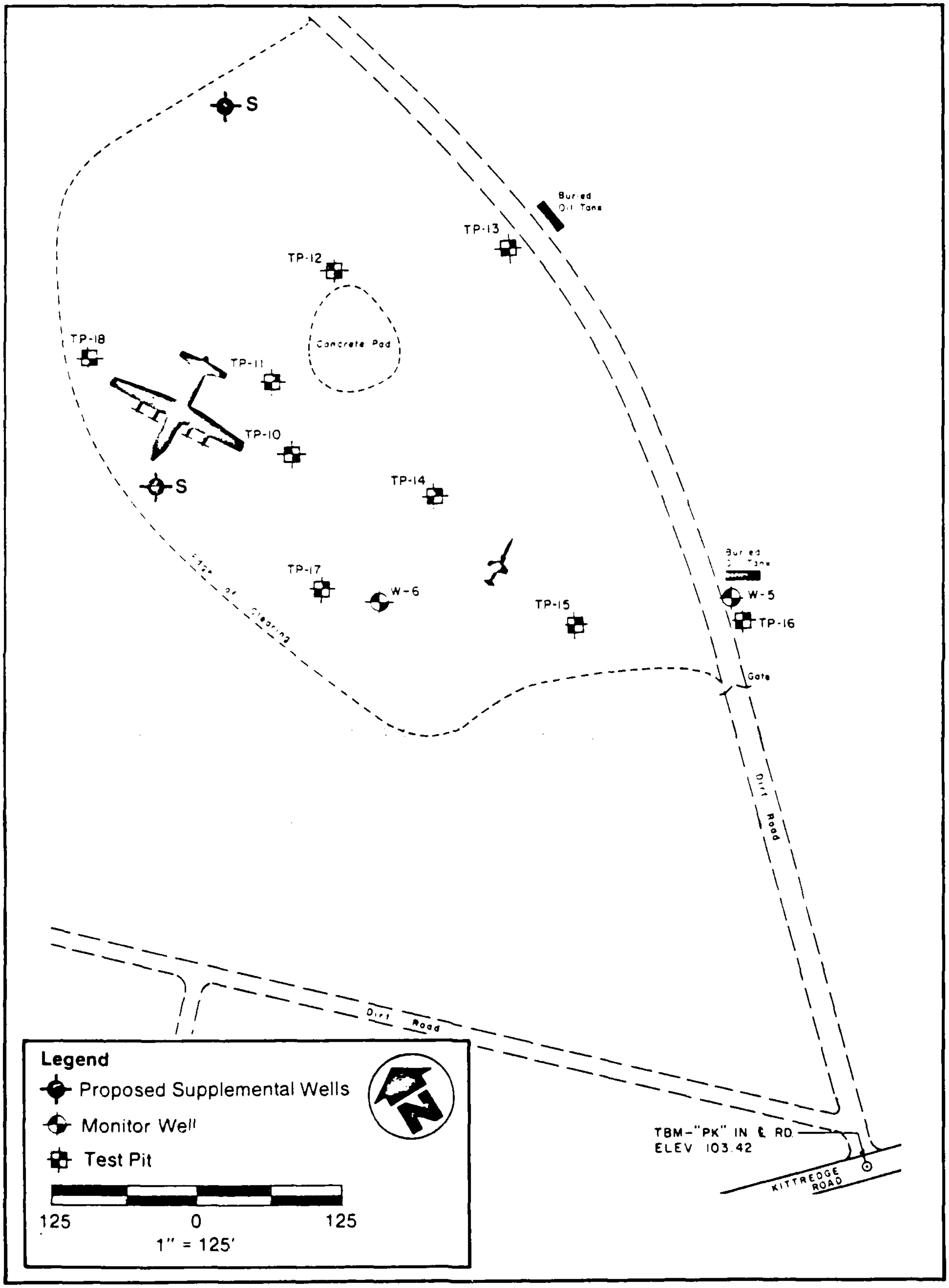

FIGURE 6-1 MAP OF CURRENT FIRE TRAINING AREA SHOWING PROPOSED SUPPLEMENTAL WELL LOCATIONS

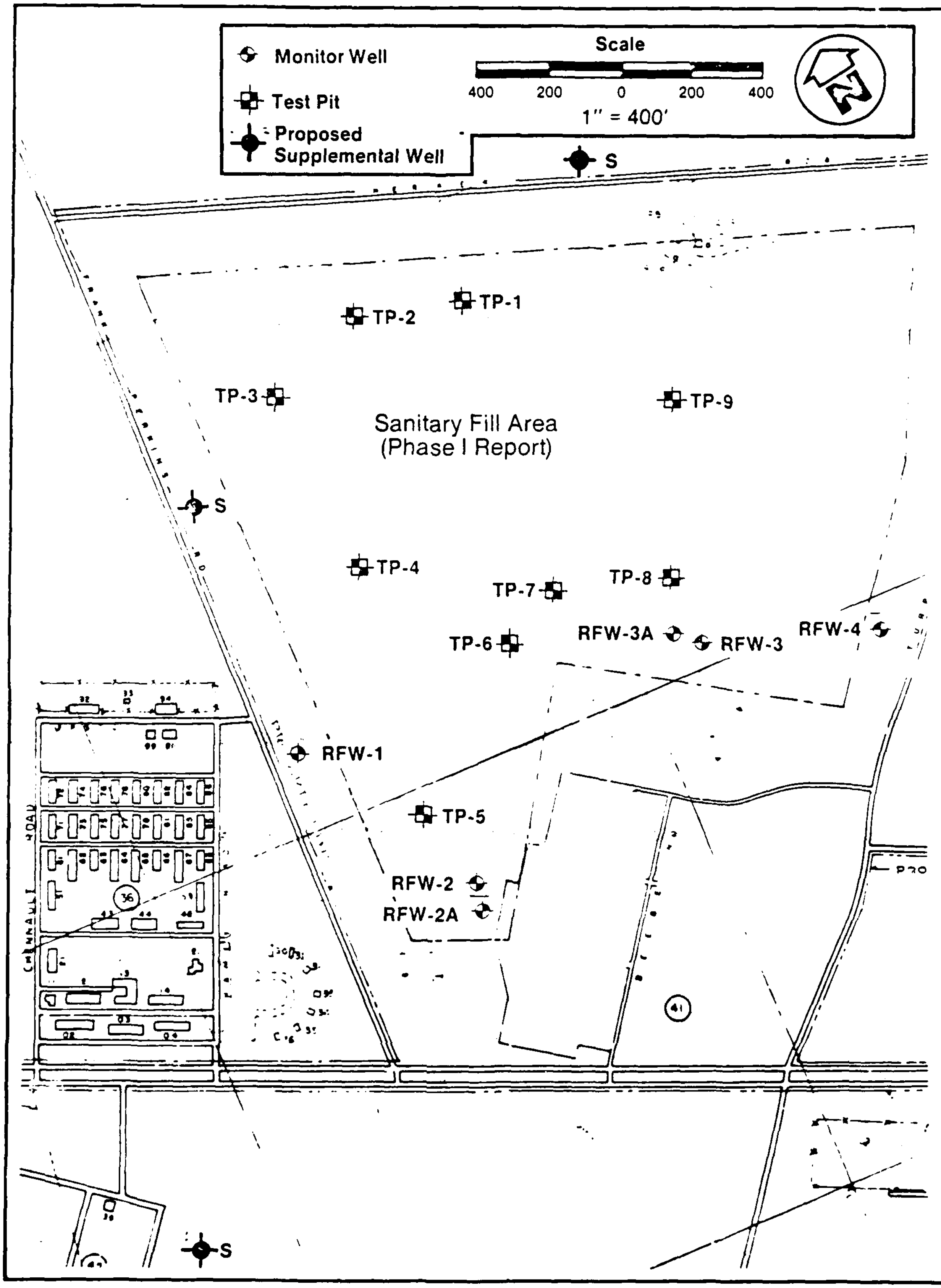

FIGURE 6-2 MAP OF BASE LANDFILL SHOWING PROPOSED SUPPLEMENTAL WELL LOCATIONS

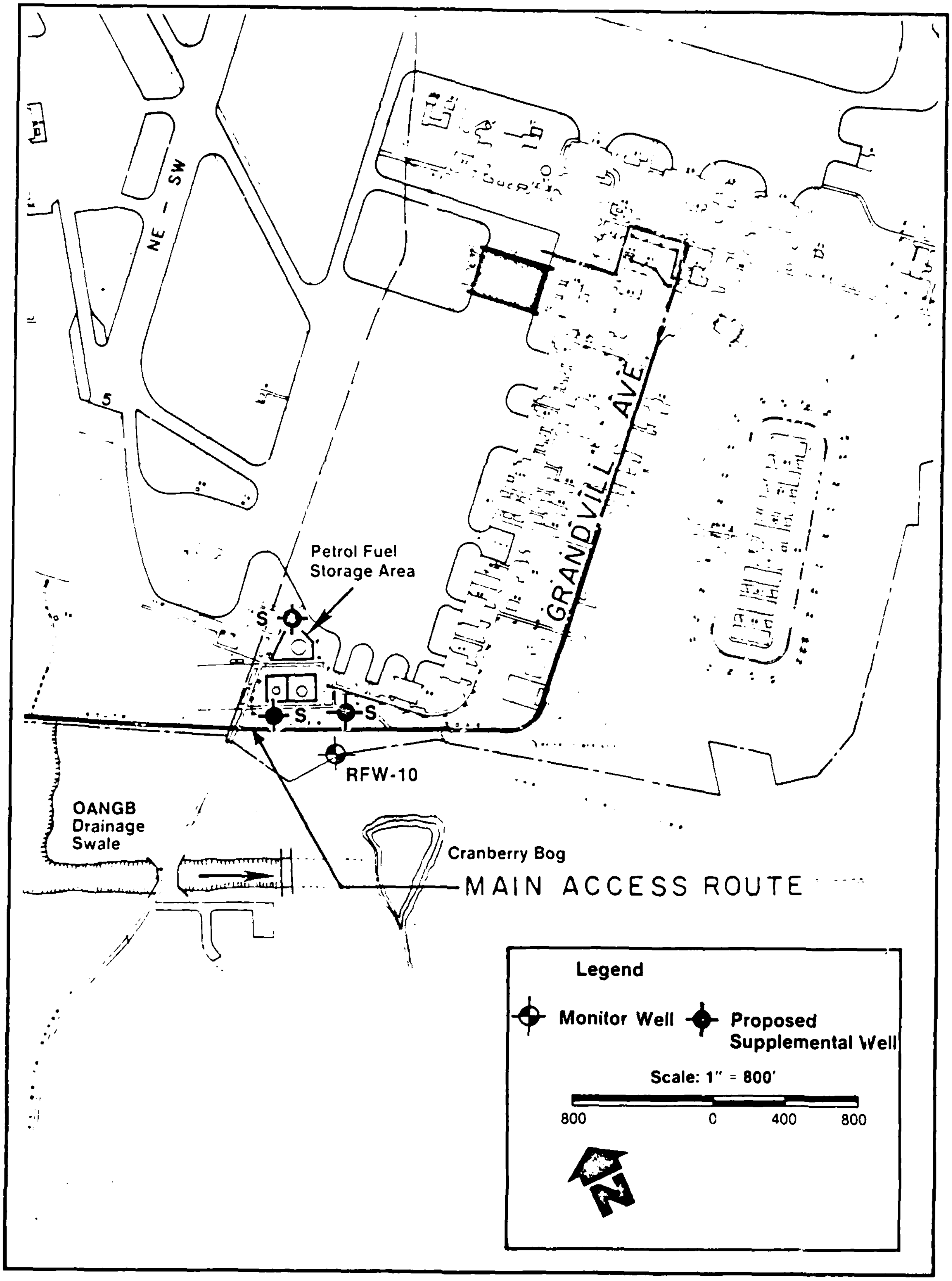

FIGURE 6-3 MAP OF PETROL FUEL STORAGE AREA SHOWING PROPOSED SUPPLEMENTAL WELL LOCATIONS

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